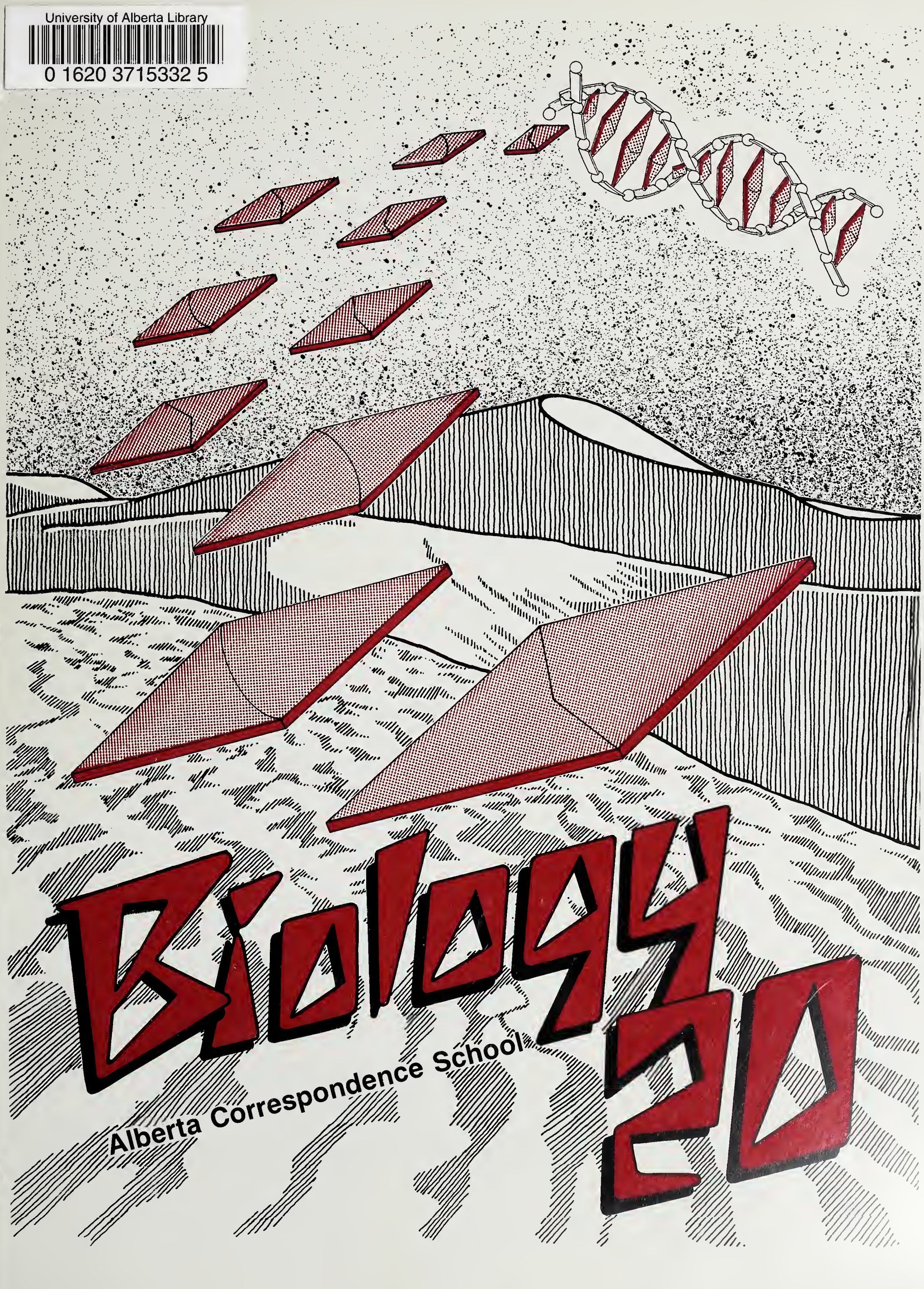
University of Alberta Library
0 1620 3715332 5



Biology 20

Alberta Correspondence School

Biology 20

Distance Learning

Alberta
EDUCATION

Biology 20
Student Module
Lessons 1-12
Alberta Correspondence School
ISBN No. 0-7741-0421-X

ALL RIGHTS RESERVED

Copyright © 1990, the Crown in Right of Alberta, as represented by the Minister of Education, Alberta Education 11160 Jasper Avenue, Edmonton, Alberta, T5K 0L2.
All rights reserved. Additional copies may be obtained from the Learning Resources Distributing Centre.

No part of this courseware may be reproduced in any form including photocopying (unless otherwise indicated), without the written permission of Alberta Education.

Every effort has been made both to provide proper acknowledgement of the original source and to comply with copyright law. If cases are identified where this has not been done, please notify Alberta Education so appropriate corrective action can be taken.

UNIVERSITY LIBRARY

Welcome

Hello. Welcome to the Biology 20 course developed by the Alberta Correspondence School. We hope that you will enjoy your studies as much as we will enjoy working with you.

We hope you will find the course interesting and relevant. It should stimulate some thought about the environment and the part you play as a member of it. Development of skills in research, understanding of biological principles and developing an awareness of the environment will be among your goals.

As a student you may find taking a course by correspondence considerably different from taking the same course in a classroom. You will likely find that much more of the onus for reading, studying and answering questions will be on you. You alone will be responsible for setting your work timetable, disciplining yourself to study each lesson thoroughly and seeing that lessons are sent in regularly.

Because your teacher is not immediately present, you will find that you will be much more involved in active, rather than passive, participation. This is an advantage to you in many ways for, as the saying goes, "we learn by doing." We hope that you will find this challenge interesting. We are confident you will succeed in your efforts if you give yourself a fair chance. We have confidence in you and your ability.

How To Begin

1. Carefully remove the staples from this workbook and put the course in a ring binder. To remove the staples, straighten the folded ends of the staples with a knife and remove the pages a few at a time until all pages are free.
2. Read the course introduction carefully. It will explain what you are going to be doing throughout the course.
3. Provide yourself with the following items: lined and unlined looseleaf sheets, "H" and "2H" pencils, a black or blue pen, a ruler and an eraser.
4. **Complete the buff coloured Course Questionnaire** and return it with the first lesson material that you send in.

The Textbook

The textbook used in conjunction with this course is:

Biology; Smallwood, W.L. and P. Alexander; Silver Burdett Company, 1984.

School students and students outside the province will have to make arrangements for the loan of this textbook through their school or else to purchase the textbook from a bookstore. All textbooks used for correspondence courses can be purchased through the Learning Resources Distributing Centre. For additional information write to

Learning Resources Distributing Centre
Alberta Education
10410 - 121 Street
Edmonton, Alberta
T5N 1L2.

The textbook is your principal source of factual material. It should be examined carefully so you are familiar with it.

Go through the **course contents** on the next page to familiarize yourself with the major topics that will be covered in each lesson.

A **dictionary of biological terms** can be found on pages 707 to 727. Use it to learn the meaning of terms you do not understand.

The **index** for this text is on pages 728 to 756. It is one of the most useful parts of the textbook when you are researching a topic.

Course Grading

Your final mark will be based on the completion of your lessons, the lab work, field work and the final test. Turn to page 12 of the Introduction for more details.

The values of the letter gradings you will receive on each lesson are as follows:

A: 80 - 100%
B: 65 - 79%
C: 50 - 64%
D: 40 - 49%
F: 0 - 39%
I: Incomplete - to be done again
R: Repeat - to be done again

Course Content

This course consists of 12 lessons. The following outline indicates the lesson content and the assigned reading from the text.

Lesson	Contents	Textbook pages
1	Individuals and Populations	Chapter 41, p. 612 to 621
2	Interactions	Chapter 42, p. 622 to 631. Chapter 43, p. 632 to 641
3	Succession and Terrestrial Habitats	Chapter 44, p. 642 to 651 Chapter 47, p. 670 to 681
4	Fresh Water and Marine Habitats	Chapter 43, p. 652 to 659 Chapter 46, p. 660 to 669
5	Man and the Environment	Chapter 48, p. 682 to 689
6	Case Study	Self contained
7	DNA, RNA and Protein Synthesis	Chapter 4, p. 53 to 64
8	Mitosis and Meiosis	Chapter 6, p. 81 to 88
9	Principles or Heredity (Part I)	Chapter 8, p. 101 to 110
10	Principles of Heredity (Part II)	Chapter 8, p. 111 to 118
11	The Theory of Evolution	Chapter 10, p. 145 to 152
12	Review Lesson	Self contained

Completing the Lessons

You will gain maximum value and enjoyment from this course if you use the following guidelines:

1. Establish a regular timetable for studying.

2. Work in an area where you will be disturbed as little as possible.

3. Have all your materials close at hand.

4. Read the material in the references, as directed by the lesson, at least once and more if necessary. Study all diagrams and charts as they are mentioned so that you will be able to relate the information in them to that in the writing.

5. After you have dealt with the text material, read the teaching notes and study any diagrams or drawings given. If possible, read all this material more than once—unless you are confident you know it.

6. Now begin the exercises. Read the questions carefully so that you understand exactly what has been asked or what you have been instructed to do. Think about your answer very carefully, then record it. **N.B. Attempt to answer all the questions in each lesson or the lesson will be returned with the grading, "Incomplete."** You will then have to complete the work and resubmit the lesson.

7. Do all written work in **blue or black** ink and on the sheets provided. Use proper English to answer the questions and write as neatly as you can. It will take anywhere from six to 10 hours to complete a lesson.

8. If you have any questions about any aspect of the course, do not hesitate to send them in or phone your Correspondence School teacher at little or no cost on the RITE phone system. See your local telephone directory for the listing under Government of Alberta, RITE Operator, then ask for 674-5333, Barrhead. We are here to help you as much as we can.

9. When submitting your lessons, send only the section marked "Exercises to be submitted for correction and grading." Pages containing only teaching notes should not be submitted. Self-test exercises should not be submitted.

10. When corrected lessons are returned to you, you should go through them carefully and correct the errors using the comments and references provided.

    When you correct your answers, your understanding in those areas which have given you the most trouble should be greatly improved. This should also result in your receiving a better final mark in the course.

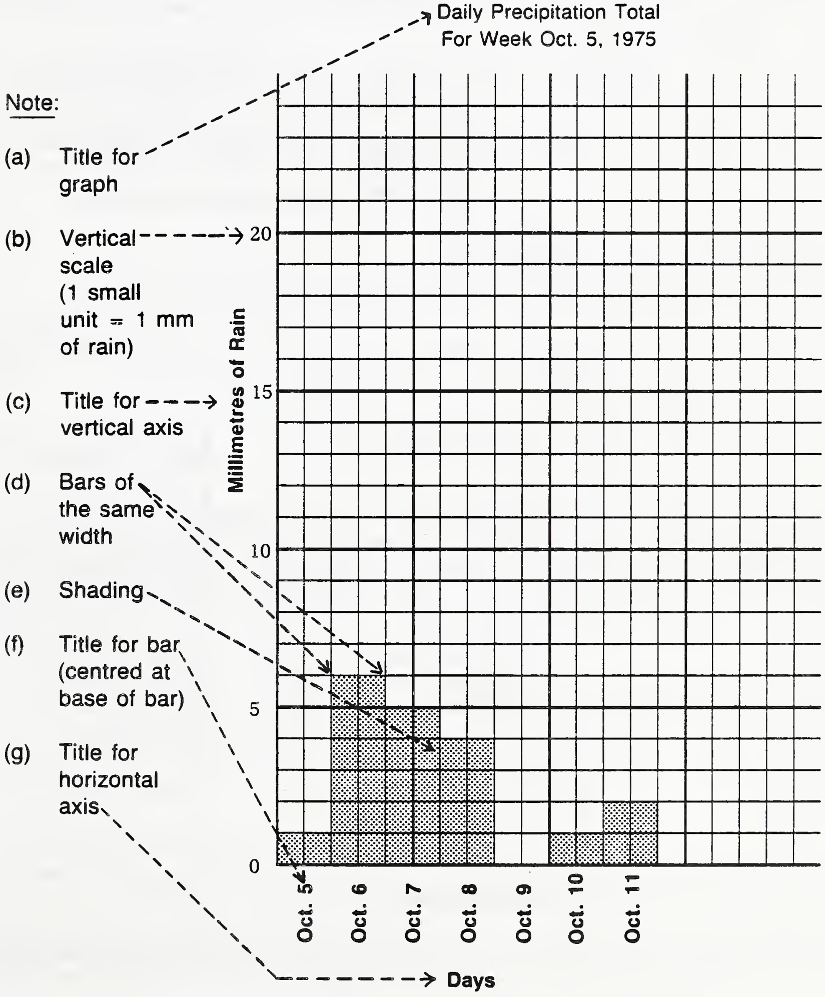
11. Submit your lessons regularly. Students who submit one or two lessons per week are more successful than those who send lessons in sporadically.

Preparation of Graphs

I. The Bar Graph

1. The bar graph is used mainly for showing general comparisons or for indicating general trends. The bars may be drawn either horizontally or vertically. Each bar represents the size of one quantity and the graph as a whole compares the sizes of various items.

2. Study the essential parts of the vertical bar graph below.



Note:

(a) Title for graph

(b) Vertical scale (1 small unit = 1 mm of rain)

(c) Title for vertical axis

(d) Bars of the same width

(e) Shading

(f) Title for bar (centred at base of bar)

(g) Title for horizontal axis

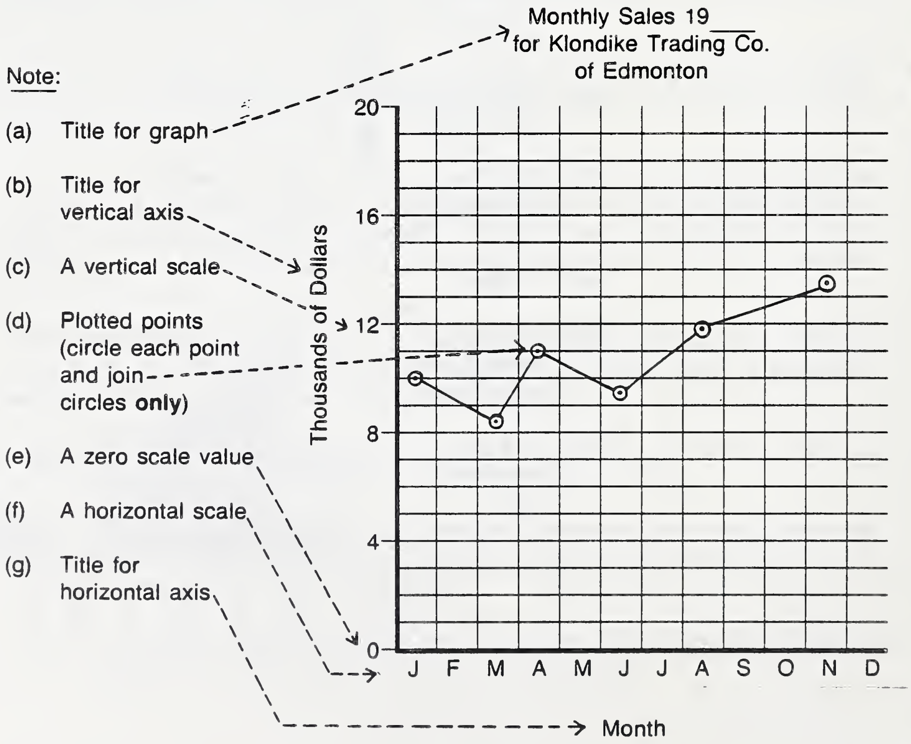
3. Select the scale for the horizontal and vertical axes in the following manner.

   (a) To determine the scale of the vertical axis, determine the units of information that have to be plotted on this axis. In the graph on page 5, the maximum number of units to be shown was **6** mm of precipitation. By selecting a scale of 1 small unit on the vertical axis equals 1 mm of precipitation, all the readings for the seven days could be graphed. If a scale of 4 small units equals 1 mm of rain had been selected, not all the readings would have fit on the graph.

   (b) To determine the scale of the horizontal axis, determine the number of units of information that have to be plotted on the axis.

   In the graph on page 5, precipitation readings had to be shown for 7 days. By selecting a scale of 2 small units on the horizontal axis equals 1 day of time, all the precipitation readings for the seven-day period were included. If readings for 14 days had to be plotted, the scale on the graph would have to be changed to 1 small unit equals 1 day in order to incorporate this information on the horizontal axis.

II The Line Graph



Note:

(a) Title for graph

(b) Title for vertical axis

(c) A vertical scale

(d) Plotted points (circle each point and join circles **only**)

(e) A zero scale value

(f) A horizontal scale

(g) Title for horizontal axis

III Points To Remember In Graphical Construction

1. The line graph on page 6 consists of numerous straight segments. This type is called a "broken-line" graph.
2. The axes should be drawn in more heavily than other lines.
3. On numbered scales, equal amounts must always be represented by equal distances. Choose scales that are easy to work with.

Examples of Good Scales	**Examples of Faulty Scales**
0, 10, 20, 30, 40, 50	0, 10, 100, 1000, 10 000
0, 50, 100, 150, 200, 250	0, 1, 3, 5, 7, 9
0, 2, 4, 6, 8, 10	0, 1, 4, 9, 16, 25

4. Example of a small scale: 500, 1000, 1500, 2000.
5. Example of a large scale: $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1.
6. Examine your data and then choose a scale which allows your graph to spread out over the space provided. (Do not cramp your graphs.)
7. Scale numbers and letters must be written along the axes.

SI (The Latest Version of the Metric System)

In 1960 the International System of Units was established as a result of a long series of international discussions. This modernized metric system, called SI, from the French name, Le **Systeme International** d'Unites, is now, as a general world trend, to replace all former systems of measurement, including former versions of the metric system. Canada has decided to convert to SI.

Many European nations are making the change to SI - a change from former metric practice. The United Kingdom, Australia, New Zealand, South Africa and others are adopting SI, while countries such as India, China and Japan are updating their metric practice to conform to SI. In the United States, major industries are tooling up for metric conversion and their choice, too, is SI.

It's SI, not S.I. - omit the periods.

It's just called SI not the "SI system," since the "S" stands for the word "system."

The course is written using SI units exclusively. The table of units on the following page is a reference guide so you can easily understand what these units mean.

PLEASE: Try to think **SI Metric** and use these metric measures whenever possible.

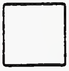
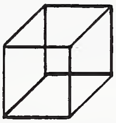
Table of Prefixes

Prefix	Symbol	Meaning	Multiplier	
tera	T	one trillion	1 000 000 000 000	$= 10^{12}$
giga	G	one billion	1 000 000 000	$= 10^{9}$
* mega	M	one million	1 000 000	$= 10^{6}$
* kilo	k	one thousand	1 000	$= 10^{3}$
hecto	h	one hundred	100	$= 10^{2}$
deca	da	ten	10	$= 10^{1}$
*		one	1	$= 10^{0}$
deci	d	one tenth of a	0.1	$= 10^{-1}$
* centi	c	one hundredth of a	0.01	$= 10^{-2}$
* milli	m	one thousandth of a	0.001	$= 10^{-3}$
micro	μ	one millionth of a	0.000 001	$= 10^{-6}$
nano	n	one billionth of a	0.000 000 001	$= 10^{-9}$
pico	p	one trillionth of a	0.000 000 000 001	$= 10^{-12}$
femto	f	one quadrillionth of a	0.000 000 000 000 001	$= 10^{-15}$
atto	a	one quintillionth of a	0.000 000 000 000 000 001	$= 10^{-18}$
* - most commonly used				

Unit	**Symbol**	**Meaning**	**Example**
terametre	Tm	10^{12} m	Distance from sun to Saturn = 1.4 Tm
gigametre	Gm	10^{9} m	About 3 times distance from earth to moon.
megametre	Mm	10^{6} m	Distance from Calgary to northern Alberta border.
kilometre	km	10^{3} m	Length of brisk 10 min walk.
metre	m	1 m	Height of 3-drawer filing cabinet.
millimetre	mm	10^{-3} m	Thickness of a dime.
micrometre	μm	10^{-6} m	Size of bacteria
nanometre	nm	10^{-9} m	Length of oil molecule
picometre	pm	10^{-12} m	Wavelength of gamma rays
femtometre	fm	10^{-15} m	Diameter of a proton
attometre	am	10^{-18} m	???

Table of SI Units and Non-SI Units Permitted For Use With SI

The table that follows is put in the order of most probable frequency of use. So units that would be used frequently are put first, and units less frequently toward the end. The conversion factors are to be used ONLY IF you are reading a book or manual that has Imperial units. You should start thinking **entirely metric** and **not about the Imperial units at all!** You should use metric measurements in your daily life **exclusively** so it becomes a matter of habit. Be modern and up-to-date! Use SI and insist that your friends use it too!

QUANTITY	UNIT	SYMBOL	NOTES
length	nanometre micrometre millimetre centimetre metre kilometre	nm μm mm cm m km	Nanometre (nm) replaces the old metric unit millimicron (mμ) Micrometre μm replaces the old metric unit micron 1 nm = .000 001 mm 1 μm = .001 mm
area	square centimetre square metre	cm^2 m^2	
volume	cubic centimetre cubic metre millilitre litre	cm^3 m^3 mL L	1 cm by 1 cm by 1 cm There are 1000 mL in 1 L. 1 L is the volume of a cube 10 cm by 10 cm by 10 cm. 
mass	gram kilogram milligram tonne	g kg mg t	1 t is 1000 kg.
temperature	degree Celsius	^{0}C	A comfortable room has a temperature of 20^{0}C. Body temperature is 37^{0}C.
time	hour minute second	h min s	
pressure	pascal kilopascal	Pa kPa	The atmospheric pressure is about 100 kPa. One millimetre of mercury or one torr is about 133 Pa.
energy, work	joule	J	1 Cal = 4.2 kJ (approx); 1 cal = 4.2 J (approx) (1 Cal = 1000 cal).
force of gravity	newton	N	Newton - the force that, when applied to a body having a mass of one kilogram, gives the body an acceleration of one metre per second squared.
Numeric dating	In SI, dates are expressed in this **exact** order: YEAR-MONTH-DAY. The month is not written out and times can be added by: hour - minute - second. Example: 1977 10 31 08 30		

Rules for Writing SI

1. Always print symbols in Roman (upright) type, irrespective of the typeface used in the rest of the text: km (not *km*).

2. Never pluralize symbols: 45 g (not 45 gs).

3. Never use a period after a symbol, except when the symbol occurs at the end of a sentence. This is because SI symbols are SYMBOLS, NOT abbreviations.

   Example: the symbol for kilogram is kg NOT kg.

4. Symbols should usually be used and unit names not mixed with symbols.

   Example: 10 kg (preferred), ten kilograms (accepted), never 10 kilograms.

5. Always use a full space between the quantity and the symbol: 45 g (not 45g)

   Exception: For Celsius temperatures the degree sign occupies the space. 32°C (not 32° C or 32 °C).

6. Use decimals, not fractions: 0.25 g (not 1/4 g) (the decimal is a point on the line in English).

7. Always use a zero before a decimal marker: 0.45 g (not .45 g).

8. Write symbols in lower case, except when the unit is derived from a proper name:

   m for metre; s for second; but N for newton; A for ampere; degree Celsius °C is the only one to be upper case in both name and symbol.

9. Print prefixes in Roman (upright) type without spacing between the prefix and the unit symbol: kg for kilogram, km for kilometre.

   Apply only one prefix at one time to a given unit: megagram or tonne, NOT kilokilogram.

10. Use spaces to separate long lines of digits into easily readable blocks of three digits with respect to the decimal marker: 32 453.246 072 5.

    Exception: A space is optional with a four-digit number: 1 234 or 1234.

11. Multiplication of Units in symbolic form is indicated by a dot at mid-letter height between the symbols: $2 \bullet 3 = 6$

12. Division of Units in symbolic form is indicated by an oblique stroke between the symbols **or** by a negative exponent: $6/2 = 3$ or $6 \bullet 2^{-1} = 3$.

ADVANCE NOTICE CONCERNING TESTING AND COURSE EVALUATION

1. In order to be recommended for credits for this subject, you are required to write a supervised test prepared by the Alberta Correspondence School before registration expires. A portion of the final mark will be based on your course work, as evaluated by the teacher of the Alberta Correspondence School. If the final mark differs substantially from the year's work, the teacher will use discretion in balancing the composition of the marks in order to arrive at a fair assessment of achievement in the course. Appeal papers will be available to all students whose registration has not expired.

2. (a) **Classroom students:**

   If you attend a school in Alberta and are supplementing your school program by taking one or more correspondence courses, you do not need to submit an application for the final test. Test papers will be sent automatically to your principal for writing before the end of the semester or at the end of August for writing during the first week of September. At least **eleven satisfactory lessons** out of the 12 to be submitted, must be received by the Alberta Correspondence School before a test paper is mailed to the principal. However, all 12 lessons should be submitted before the test is written, since you will lose marks for the course work portion if only 11 lessons are submitted.

   Please note that **Lesson 6** for Biology 20 **must be submitted prior to writing the exam**, otherwise the 10 per cent awarded for it towards the final mark will be forfeited.

   Your school principal is in charge of scheduling final tests. All questions about scheduling should be directed to your principal.

   If a test is not written before your registration expiry date, the course is considered incomplete for the school year which you registered.

   (b) **Non-classroom students:**

   If you are studying exclusively by correspondence, and are not registered in any subjects in an Alberta classroom, then to obtain course credits, you must complete all required lessons and write the final test before your registration expires. Information about expiry dates is given in the Information Bulletin which you received before filing your application for a correspondence course.

   The application for the final test is sent out when corrected Lesson 6 is returned to you. You should submit the application to the Alberta Correspondence School as soon as possible.

   The test is sent out after **11 SATISFACTORY LESSONS**, out of 12 to be submitted, have been received by the Alberta Correspondence School. However, all 12 lessons should be submitted before the test is written, since you will lose marks for the course work portion if only 11 lessons are submitted.

If a test is not written before registration expires, the course is considered incomplete for the school year during which you are registered.

NOTE: For the purpose of writing final tests, students who live outside Alberta come under the same regulations as those in category (b).

HOW YOUR FINAL GRADING WILL BE ARRIVED AT

Because of the nature of correspondence study and the lack of face-to-face communication between teacher and student you are required to write a final supervised test in this course. **This test will constitute 70 per cent of your final grading.**

Your final grading will be determined as follows:

Lessons 1-5 and 7-12	**20/**
Case Study (Lesson 6)	**10/**
Final exam	**70/**
Total	**100/**

Writing Your Final Test

Your final test is based entirely on the material covered in your course, so the only adequate preparation for the successful writing of the test is a thorough knowledge and understanding of the subject matter of the course.

You may not refer to any textbooks, notes, corrected lessons or other references during your test.

You may use mechanical or electronic calculators on all final tests. Note, however, that if you use a programmable calculator, the memory must be cleared before you begin your final test.

With the exception of special medical cases where prior arrangements have been made, you will be allowed only that period of time indicated on the test for its completion. As a general rule, 5-credit courses provide for up to two hours for the final test, and 3-credit courses provide for up to one and one-half hours, while some tests in diploma examination subjects require up to two and one-half hours.

If disturbances or interruptions are encountered while you are writing your test, please note them briefly and clearly in the space provided on the declaration form at the front of the test and have them verified by your supervisor.

Time of Writing

You should plan to write your test as soon as possible after completing your course. Please arrange with your supervisor for a mutually suitable time and place of writing.

All tests must be written before your registration expires, although eligible students may have their registrations extended where necessary, to provide for additional time for the completion of courses and final tests.

END OF INTRODUCTION

A LESSON RECORD FORM MUST BE COMPLETED FOR EVERY LESSON SUBMITTED FOR CORRECTION, AS ILLUSTRATED BELOW

A Lesson Record form with the **correct** label attached **must** be enclosed with **every lesson** submitted for correction, as illustrated below.

Correct use of these labels will ensure prompt processing and grading of your lessons.

The enclosed **Lesson Labels** must be checked for spelling and address details.

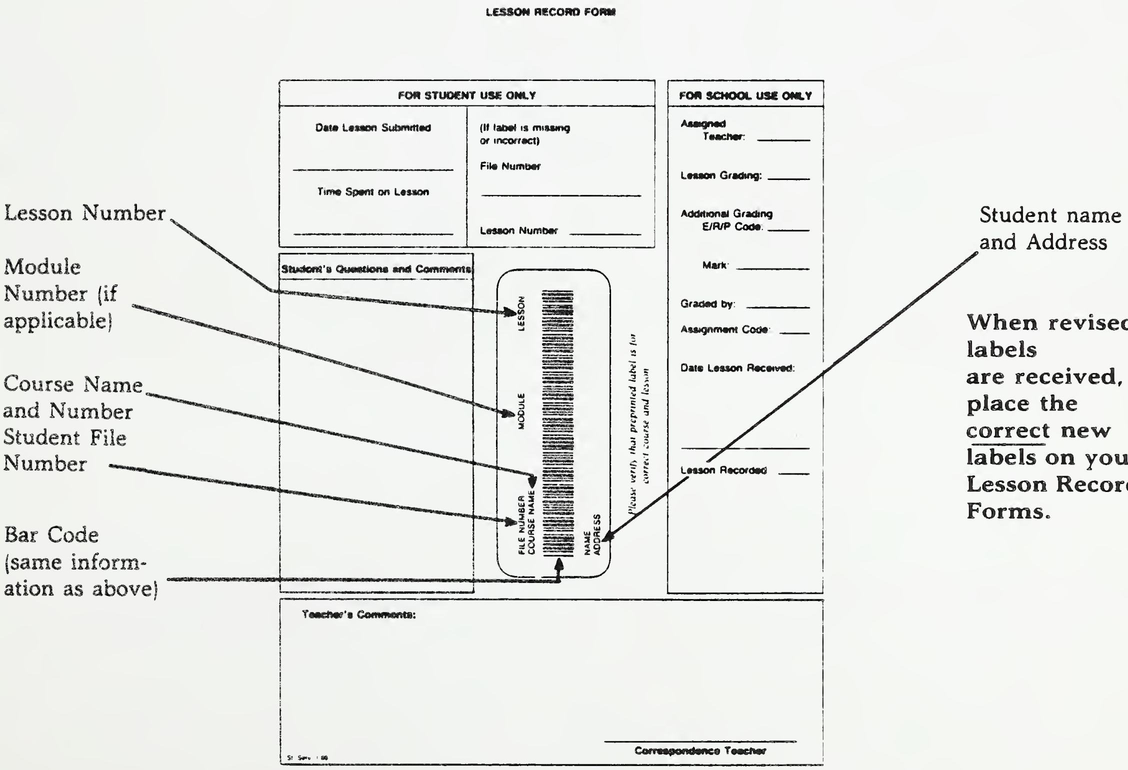
Please advise the Alberta Correspondence School promptly of any changes in name, address, school, or any other details and we will issue a revised set of labels. Your file number is permanently assigned and **must** be included on all correspondence with the Alberta Correspondence School. If the proper label and Lesson Record Form is not attached to each lesson as indicated it will delay your lessons being processed and credited to you.

Lesson labels are to be attached to the **lesson record forms** in the space provided for student name and address.

Check carefully to ensure that the **subject name, module number** and **lesson number** on each label corresponds exactly with the lesson you are submitting.

Labels are to be **peeled** off waxed backing paper and **stuck** on the lesson record form.

Only **one** label is to be placed on each lesson.



LESSON RECORD FORM

FOR STUDENT USE ONLY

Date Lesson Submitted

Time Spent on Lesson

(If label is missing or incorrect)

File Number

Lesson Number

Student's Questions and Comments

Please verify that preprinted label is for correct course and lesson

FOR SCHOOL USE ONLY

Assigned Teacher:

Lesson Grading:

Additional Grading E/R/P Code:

Mark:

Graded by:

Assignment Code:

Date Lesson Received:

Lesson Recorded

Teacher's Comments:

Correspondence Teacher

When revised labels are received, place the correct new labels on your Lesson Record Forms.

DO NOT MARK OR COVER BAR CODING.

CHANGE OF ADDRESS

If the address on your lesson record form differs from the address you supplied on your registration application, please explain. Indicate whether the different address is your home, school, temporary or permanent change of address.

St.Serv. 3-88

LESSON RECORD FORM

2230 Biology 20
Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ____________________

Time Spent on Lesson ____________________

(If label is missing
or incorrect)

File Number ____________________

Lesson Number ____________

FOR SCHOOL USE ONLY

Assigned Teacher: ________

Lesson Grading: ________

Additional Grading E/R/P Code: ________

Mark: ________

Graded by: ________

Assignment Code: ______

Date Lesson Received: ____________

Lesson Recorded ______

Student's Questions and Comments

Apply Lesson Label Here

Name ____________

Address ____________

____

____

Postal Code ____________

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____
Correspondence Teacher

St. Serv. 1-88

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

ECOLOGY VIDEOTAPES

A series of 5 very interesting half-hour programs on ecology has been prepared by ACCESS Alberta to complement the first five lessons of the Biology 20 course. The viewing of these programs, while optional due to the availability of videotape players, is highly recommended.

Though the Alberta Correspondence School cannot supply a videotape player, it is suggested you make arrangements for the use of a machine through your school, a friend or a local rental outlet.

Each half-hour program can be viewed with the appropriate lessons or all 5 programs can be viewed at the end of the five lessons as an overview of ecology. The suggested viewing order for the five programs is:

1. Populations - View with Lesson 1.
2. Circles and Cycles - View with Lesson 2.
3. Ecosystems - View with Lesson 3.
4. Biomes - View with Lesson 4.
5. Microorganisms - View with Lesson 5.

Use the following order form to acquire these tapes if you wish to view them. Also note that none of the questions in your lessons are based on the programs. This is strictly optional, supplementary material.

Keep this sheet as a guide to the viewing order of the programs.

APPLICATION FOR OPTIONAL BIOLOGY 20 VIDEO PROGRAMS

(Videotape sent only if requested by the student)

This material is optional and is intended as a supplementary resource for Biology 20.

Name:____________________________________ File Number: _______________

Address: ____________________________________

____

____

____

Check Video Format

☐ VHS ½'' cassette

☐ Betamax ½'' cassette

Item in Loan Kit

One VideoTape

Program 1 - Populations
Program 2 - Circles and Cycles
Program 3 - Ecosystems
Program 4 - Biomes
Program 5 - Microorganisms

Qualifications for Loan Item:

1. The loan cassette is not available to students with an address outside Alberta.
2. The loan cassette is available only to students in Biology 20. Schools may purchase the program from ACCESS.
3. The cassette is loaned for a two-month period and if lost must be paid for by the student at a cost of $11.00.
4. Students must have a video cassette player available in order to make use of these cassettes.

____

(Signature of Applicant)

ECOLOGY

Introduction

Hi! let's get started on the first lesson of Biology 20. If you have not read the course "Introduction" preceding Lesson 1, do so before starting this lesson.

If you recall your studies in Biology 10, you should remember that you studied many different kinds of microorganisms, plants and animals are present on earth. You learned a bit about the structure of each organism, how the different parts of each organism operate, the taxonomic relationship between organisms and how each organism goes about its way of life. We will now pursue the study of organisms from an ecological point of view.

Ecology is a branch of biology that deals specifically with the relationships between living organisms and their environment.

No organism is isolated from its surroundings. It is brought to life by its parents to live and eventually die. Air, water, soil, plants and animals make up the surroundings of every living thing.

By the very nature of being alive organisms interact with the things that surround them. A tree takes water from the soil, carbon dioxide from the air and light from the sun to make its own food through photosynthesis. A caterpillar may eat the leaves of the tree. It in turn may be eaten by a bird. And so it goes. These are the types of interactions we will be looking at in our study of ecology.

As you may also recall, the components that make up living things and living things themselves, can be organized to show successively higher *levels of organization*. Let us now take a look at this heirarchy of organization.

Read sections 1-4 to 1-7 in your text, pages 3 to 6. Pay particular attention to Fig. 1-1. Once you have read the four sections, return to these notes and continue reading.

In the following list note the most basic level of organization is the **element** and that complexity increases as one moves to the highest level, the **ecosphere**.

ELEMENT (atoms)
↓
COMPOUND (molecules)
↓
ORGANELLE
↓
CELL
↓
TISSUE
↓
ORGAN
↓
ORGAN SYSTEMS (system)
↓
ORGANISM (individual)
↓

POPULATION
↓
COMMUNITY
↓
ECOSYSTEM
↓
SPECIES
↓
BIOSPHERE
↓
ECOSPHERE

1. **Element.** Elements are the most fundamental materials from which all other materials are made. They cannot be reduced to simpler substances by chemical means. An atom is the smallest part of an element that can enter a chemical reaction. Some examples of elements are carbon, oxygen and hydrogen. These elements and many others are present in living matter.

2. **Compound.** A compound is a substance composed of two or more chemically combined elements. When atoms from one or more elements combine they form **molecules**. A molecule is the smallest unit of a substance which still retains the chemical properties of the substance. The smallest unit of a compound is a molecule. Examples of compounds are water, (H_2O), carbon dioxide (C_2O), and sucrose ($C_2H_{12}O_6$). Living matter is made up of compounds such as fats, protein and carbohydrates. These are combined to produce the different parts of the cell.

3. **Organelle.** Within the living contents of a cell are specialized bodies made up of compounds and elements. These bodies, known as **organelles**, carry out essential functions for the cell. For example, mitochondria carry out respiration and chloroplasts carry out photosynthesis.

4. **Cell.** The cell, composed of a variety of compounds and organelles, is the basic unit of life. Cells can exist singly or in groups. Cells which function independently are known as **unicellular organisms**. Some examples of unicellular organisms are yeast, bacteria and euglena. A colony consists of similar living cells that are attached to each other but function independently of one another. In multicellular organisms there is a division of labor amongst specialized cells to maintain the whole organism. Some examples of specialized plant cells are xylem, phloem and cambium cells. Some examples of specialized animal cells are bone, muscle and nerve cells.

5. **Tissues.** In multicellular organisms, similar cells are organized together to perform a specific function. This level of organization is known as tissue. Some examples are muscle, marrow, cambium and epidermis.

6. **Organs.** Organs are found in advanced multicellular plants and animals. They consist of two or more tissues which work together to carry out one or more life processes. The plant root is an organ, as is the human heart.

7. **Organ Systems.** The organ system consists of two or more organs working together to perform a specific function or functions. Systems are only found in advanced animals. Examples of organ systems are the nervous system and circulatory system. The circulatory system is made up of heart, blood vessels and blood.

8. **Organism.** An organism is any entire living thing. Organisms can be unicellular; carrying out all life functions within a single cell. In multicellular organisms, functions are carried out by groups of cells at various levels of organization.

9. **Population.** A population is a group of organisms of a specified kind that occupy a space at any point in time. For example, all the fish of the species *Esox lucius* (pike) in Lake Wabamun in October 1983.

10. **Community.** All the different species populations that make up the living portion of an ecosystem. For example, all the plants, animals and protists, etc. that live near and within Lake Wabamun.

11. **Ecosystem.** An ecosystem combines the living community of organisms and the non-living physical environment in which they live. If we consider Lake Wabamun as an example of an ecosystem, it consists of all living organisms such as birds, fish, insects, algae and emergent plants as well as the non-living factors such as lake water, air, the mud at the lake bottom, sunshine, and wind. All the non-living factors can be collectively referred to as **abiotic** factors. All living organisms in the ecosystem would then be referred to as **biotic** factors.

12. **Species.** Eventually we have to start looking at life at the global level. Some organisms are very specialized and are only found in a few places around the world (e.g. polar bear), while others are more common and may be found almost anywhere in the world (e.g. bacteria). When we look at all the populations of a particular type of organism present in the world, we are referring to a species. All the people in the world are referred to as the species *Homo sapiens*. All the robins in the world are referred to as the species *Turdis migratorius*.

13. **Biosphere.** The biosphere is the total of all species living on earth. It includes every living thing.

14. **Ecosphere.** The ecosphere consists of all ecosystems on earth. It includes all living organisms and the interactions they have with the non-living (abiotic) physical environment that surrounds them.

Populations

You will be studying the concept of populations in greater depth than the topic is dealt with in the text, so read the materials from the text first, then return to this lesson.

READ

Read section 41-1 to 41-5 of your text (pages 613 - 616).

A population can be defined as a group of organisms of a specific kind that occupy a designated space at a specific point in time. In defining a population, there are four distinct variables to deal with:

1. The *kind* of organism that makes up the population.
2. The *quantity* or number of individuals in the population.
3. The *space* (area or volume) in which the population is found.
4. The *time* at which the population exists.

Often literature about populations will have one or more of these variables implied when the meaning of the variable seems apparent from the context in which it is stated. For instance, if I said to you, "The population of Edmonton is 655 000," three of the four variables would be implied.

First you must assume that the type of organism being referred to is man. You also would assume that the time at which the population count was taken is close to the present. Finally the space, Edmonton, has only been defined in the vaguest way; not as a measurement of area or volume. The only variable that is clearly defined is the quantity or number of organisms; in this case 655 000.

When dealing with populations in biology, these variables must all be clearly defined. Numerical values can be assigned to the number of organisms, the space and the time. The scientific name of the species can be assigned for the kind of organism.

An example of a population defined in this way would be 10 500 honeybees (*Apis mellifica*) in a cloverfield of 105 ha, 10 km west of Olds, Alberta on July 12, 1984. By assigning numerical values to the data one can make it very precise and much more useful to the scientist. With this data the ecologist could calculate the density of the population and compare densities from one location to another, one habitat to another, or one month or year to another in the same habitat.

Characteristics of Populations

A population is a unique level of organization. Its properties go beyond those of the individuals that make it up. A population exhibits structure and organization. It has a past, present and future. Let us now take a closer look at the characteristics of population.

In order to calculate the density (D) of a population, two things must be determined. First count the number (N) of individuals in the population and then determine the amount of space (S) they occupy. The space occupied by terrestrial organisms is usually expressed in two-dimensional units such as square metres (m^2). The space occupied by aquatic organisms is usually stated in three dimensional units, such as cubic metres (m^3). To determine the density (D) of a population, divide the number of individuals (N) by the amount of space (S).

$$D = \frac{N}{S} \quad \text{or} \quad \text{Density} = \frac{\text{Number of Individuals}}{\text{Space (area or volume)}}$$

Area = length × width   Volume = length × width × height

Let us see how the formula works. After digging up and sifting through two cubic metres of soil 38 earthworms and one soil beetle were found. The density of the earthworms would be:

$$D = \frac{38 \text{ earthworms}}{2 \text{ m}^3} = 19 \text{ earthworms per m}^3$$

The density of the soil beetles would be:

$$D = \frac{1 \text{ soil beetle}}{2 \text{ m}^3} = 0.5 \text{ soil beetles per m}^3$$

Note that a density is properly expressed only when it states the number of individuals *per unit* of space. For instance, if there were 400 spruce trees in a 20 km^2 plot of forest, the density is not properly expressed until the number of individuals (400 spruce trees) is divided by the amount of space (20 km^2) to show the number of individuals per unit of space; in this case 20 spruce trees *per* km^2.

B. Rate

Populations are not static; their numbers change over time. New individuals may be born into a population, others may die. Some individuals may leave one population to join another, others may enter from an outside population. All these factors change the size of the population. If there is no change in the space which the population occupies, then any changes in population numbers result in corresponding changes in population density.

Whenever the quantity of one object varies directly in relationship to units of another, the change can be expressed as a rate. For instance, if a yeast population increases by 1200 cells in 24 hours, its rate of increase could be stated as 1200 cells per day or 1200 cells ÷ 24 hours = 50 cells per hour. The factor that varies is the number of yeast cells and the unit it varies in relationship to is the day or the hour.

1. Population Changes

It is easy to see that population numbers vary with respect to time, therefore changes in population size can be expressed as a rate. If mice in a farmer's field decrease from 275 to 150 between 1975 and 1985, how can we calculate the rate of change in the population?

The change in time, ΔT, (pronounced "delta T") is 10 years (1985 – 1975). The symbol "Δ" is known as delta and means "the change in." The change in population numbers ΔN (pronounced "delta N") is – 125 mice (150 mice – 275 mice). Note the population numbers must be shown in the same order as the dates. To calculate the rate of change in population size, divide the change in number by the change in time and you get:

$$\frac{-125 \text{ mice}}{10 \text{ years}} = -12.5 \text{ mice per year}$$

In other words, the mouse population decreased at a rate of 12.5 mice per year.

The mathematical formula used for calculating the rate of change in population size can be summarized as:

$$\text{(rate of change of population) } R_p = \frac{\Delta N \text{ (change in number)}}{\Delta T \text{ (change in time)}}$$

Suppose the population then increased to 200 mice by the year 1990. Using the formula we could calculate the change in population.

$$R_p = \frac{200 \text{ mice} - 150 \text{ mice}}{1990 \text{ yrs} - 1985 \text{ yrs}} = \frac{+50 \text{ mice}}{5 \text{ years}} = +10 \text{ mice per year}$$

In other words, the population increased at a rate of five mice per year.

We have seen that populations can go up and down with time but we have not looked at the underlying causes. There are four factors that cause populations to increase or decrease. The two factors that work to *increase* a population are *natality* (reproduction) and *immigration*.

The two factors that work to *decrease* a population are *mortality* (death) and *emigration*.

When we look at these factors in terms of a population they must be thought of as rates (i.e. birth rate, death rate). Individuals may be born, migrate between populations and die but they don't have a birth rate, migration rate or death rate; these are solely the characteristics of a population.

(a) **Natality or Birth Rate** - The rate at which new individuals are added to a population by reproduction. For animals, it includes *asexual reproduction* by fission, mitosis, spore formation, fragmentation, and budding and *sexual reproduction* by conjugation, fertilization and parthenogenesis. In plants asexual reproduction occurs by fission, budding, spore formation, fragmentation, runners, and offsets, while sexual reproduction occurs by conjugation, fertilization and seed formation.

The rate at which organisms are able to reproduce is highly variable. Some organisms reproduce only once in a lifetime while others do so numerous times. Some produce numerous spores, seeds or gametes, while others produce only a few at a time. Some organisms reach sexual maturity in a few minutes (bacteria) while many take years or even decades. These variations in the reproductive features of a population help determine its potential growth rate.

When conditions are ideal for a population, nothing will limit its growth. Under ideal conditions a population will reach its maximum rate of reproduction or its *biotic potential*. Biotic potential varies from species to species within an ecosystem due to the differences in life history and reproductive features of each.

(b) **Mortality or Death Rate** - The rate at which organisms are lost by death from a population. While reproduction is the only factor that operates to increase the size of a population, there are many factors that operate to decrease the size of a population. Predation, disease, lack of suitable habitat, competition for resources, food shortage, water shortage, change in climate and old age are some of the many factors that may result in their death.

Cumulatively the causes of death can be thought of as *environmental resistance*. At any time a population size is equal to its biotic potential (reproductive capability) minus its environmental resistance (all factors causing death in the population). If biotic potential exceeds environmental resistance the population will increase. If environmental resistance exceeds biotic potential long enough, a population may become locally extinct.

(c) **Immigration and Emigration Rate** - The immigration rate is the rate at which individuals move into a population from outside populations. Emigration is the rate at which individuals leave a population to enter other populations or form new populations in other locations.

Do not confuse immigration and emigration with migration. In migration the entire population changes the location in which it lives. In so doing the population does not increase or decrease the size.

2. Density changes

Just as there can be changes in the size of a population there can also be changes in the density of a population. Rate of change in density is the net increase or decrease in density of a population over a period of time. It can be a negative value when a population is decreasing or a positive value when a population is increasing. The formula for calculating the rate of change in density is:

$$\text{(rate of change in density) } R_d = \frac{\Delta D \text{ (change in density)}}{\Delta T \text{ (change in time)}}$$

The following example will show how to use this formula to calculate the rate of change in population density.

At the beginning of 1970, there was a population of 600 spruce tree seedlings occupying a plot 40 m by 50 m. In 1982 the plot was reduced to 30 m by 50 m in which there were 360 trees. What is the rate of change in density for this period of time?

In 1970 the density was $\frac{600 \text{ trees}}{40 \text{ m} \times 50 \text{ m}} = \frac{600 \text{ trees}}{2000 \text{ m}^2} = 0.3 \text{ trees/m}^2$

In 1982 the density was $\frac{360 \text{ trees}}{30 \text{ m} \times 50 \text{ m}} = \frac{360 \text{ trees}}{1500 \text{ m}^2} = 0.24 \text{ trees/m}^2$

Using the formula $R_d = \frac{\Delta D}{\Delta T}$, you would get:

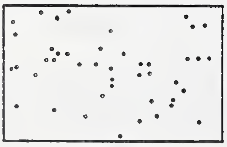
$$R_d = \frac{0.24 \text{ trees/m}^2 - 0.3 \text{ trees/m}^2}{1982 - 1970} = \frac{-0.06 \text{ trees/m}^2}{12 \text{ years}} = -0.005 \text{ trees/m}^2\text{/year.}$$

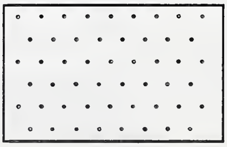
The minus figure indicates that the population density has decreased over the given period. Since spruce trees are not motile (able to move), we can assume the decrease in density was due to mortality. The population decreased in density by 0.005 trees per square metre per year.

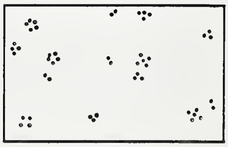
C. Dispersion

This is the way that individuals are distributed through the space they occupy. Under natural conditions organisms can be "dispersed" by their own active movement (walking, swimming, flying) or passively by wind, water, or other living organisms. The means of getting from one place to another is known as **dispersal**. The pattern of distribution that results is known as **dispersion**.

There are three basic patterns of dispersion for individuals in a population, **random, uniform, and clumped**.


Random


Uniform


Clumped

In the random pattern individuals have been distributed by chance, therefore the probability of finding an individual at any one point in an area is the same for all points. Populations that exhibit this type of dispersion would occur among free floating diatoms or plants whose seeds are distributed by the wind.

In uniform distribution there is a regular distance between individuals, much as one would find in an orchard. This type of pattern is also found naturally in forests, because trees need a certain amount of space in which to grow. Territorial animals also exhibit this type of distribution.

Clumped distribution is the most common form. In this type of distribution organisms may form loose aggregations of two or three individuals or large numbers of individuals may form lesser clumps such as clusters, flocks, herds and colonies.

D. Growth Forms

The growth form of a population is the pattern of increase or decrease that occurs over a period of time. The growth form of a population can be illustrated by plotting time on the horizontal axis of a graph and number of organisms on the vertical axis. Time can be expressed in minutes, hours, days, years or decades. Number of organisms can be an expression of total population size or density.

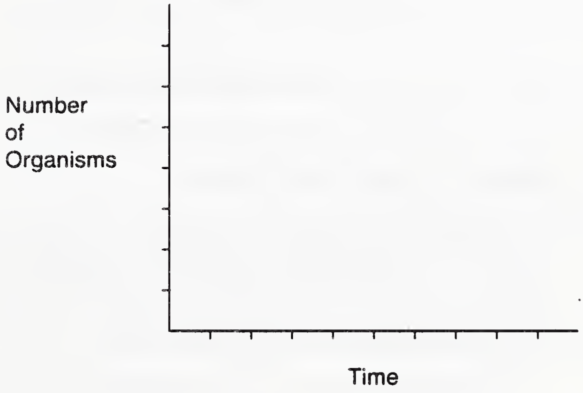


Figure 2 - Plotting a Growth Curve

You will remember that biotic potential is the maximum reproductive rate a population can achieve under ideal conditions. Some of the variables that affect this rate are the number of offspring produced per parent, the amount of time to reach reproductive maturity, the life span of the organism and the frequency of offspring production.

All these factors help determine the rate at which a population is able to increase. Some organisms, such as bacteria, can double their numbers every few minutes. Other organisms, such as elephants, have relatively low reproductive rates, taking many years to increase in numbers.

To summarize, it can be said that the increase in size of a population over a specified period of time is equal to the rate of reproduction times the number of reproductive individuals in the population at the start of the period. For example, a population of one hundred reproductive individuals that has a reproductive rate of five offspring per year would increase in size by 5 × 100 = 500 individuals in one year.

Assuming no limiting factor in the environment, a population can increase in size at a geometric or exponential rate. That is, it will increase in size at an ever increasing rate per unit of time. In other words, the population will increase in number by some factor of multiplication per unit of time. *Thus all populations have the potential to produce offspring at a rate far in excess of the replacement levels of the parent population.*

This kind of growth would be exemplified in a population able to double in size every day. On the first day there would be one individual; on the second day, two; on the third day, four; and by the fourth day, eight individuals. By the twentieth day there would be 524 288 individuals. When we plot this data on a graph we have what is known as a *J-shaped growth curve.*

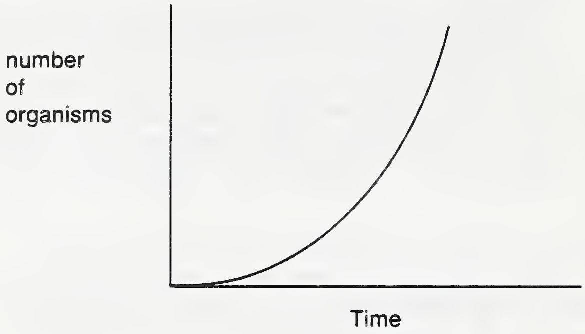


Figure 3 - J-shaped Growth Curve

Of course no population can maintain such a growth rate. Environmental resistance in the form of one or more limiting factors will eventually slow the growth rate of the population, to the point where it will level off or even decrease. Once a population reaches the size its surrounding environment can support, it is said to have reached the **carrying capacity** of its environment.

A **limiting factor** is any variable factor in the environment whose particular level at a given time restricts some activity of an individual or population of organisms. Let us now take a look at what some of these limiting factors are.

- the type and amount of food available for consumers.

- the intensity and duration of light available to producers.

- the availability of nutrients such as carbon dioxide, nitrogen, potassium and phosphorus for producers.

- the availability of space.

- whether competition from within the species (intraspecific) or from other species (interspecific), exists.

— the presence of predators, parasites and disease-causing organisms.

— the temperature throughout the year.

— the availability of nesting sites.

Almost anything affecting the lives of organisms could be considered a limiting factor.

Other factors also affect the growth forms of a population. These are:

— whether the population is open (free to immigration and emigration) or closed (no immigration or emigration).

— whether the population is new in its environment or an established population.

— whether the environment is favorable or unfavorable.

— whether the population is influenced by seasonal changes in weather or behavior.

— whether the population is influenced by the habits of man.

— the average life span of individuals in the population.

— the size of the organisms comprising the population.

— the food level the population occupies; whether they are producers, first order consumers, second order consumers, etc.

The number of possible factors that can be involved, plus the fact that these factors may operate independently or in conjunction with one another makes correlating the growth curve and the factors causing the growth curve exceedingly difficult.

Let us now take a look at a few types of growth curves and the underlying factors that cause these changes in population numbers. Many organisms exhibit what is known as an *S-curve growth pattern*.

This growth pattern is typical of organisms establishing a population in a new environment. Population increase will be slow at first as there are only a few individuals available to produce new offspring in the population.

As more offspring are produced, the rate of increase in the size of the population goes up rapidly as there are now more individuals to produce new individuals.

Eventually environmental pressures will slow the rate of increase in the size of the population. As these environmental factors become more and more limiting, increases in numbers must level off as the population approaches the carrying capacity of the environment. If the population has exceeded the carrying capacity, there must be a decrease in the size of the population.

Once a population levels off at the carrying capacity of the environment it can be said that the population is in a state of homeostasis with its environment.

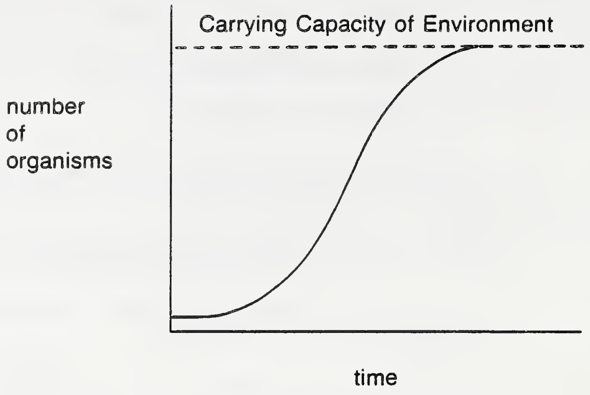


Figure 4 - S-shaped Growth Curve

One variation of the S-shaped growth curve is exhibited by insects in the temperate zone. In late spring the population begins to increase slowly and then more rapidly into summer as food supply and numbers increase.

The population reaches its peak in early autumn, then decreases rapidly because the adults die with the coming of frosts and freezing weather.

Before the adults die, they deposit their eggs. The eggs remain dormant through the winter. The following spring the insects hatch out to begin another increase. This pattern would repeat from year to year.

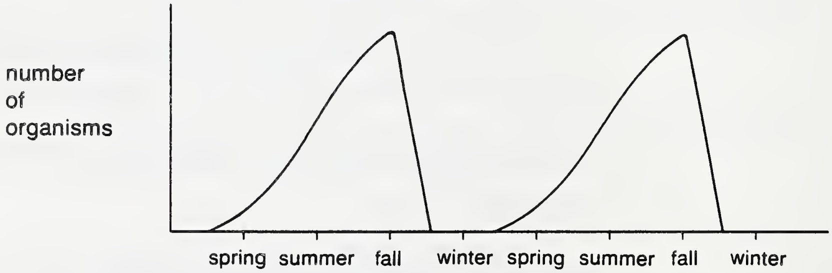
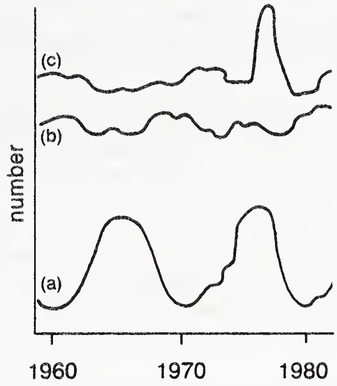


Figure 5 - An Insect Population in the Temperate Zone

Once a population becomes established in an area, its numbers may be maintained at a level close to the carrying capacity of the environment. This is true for many species of organisms. For other species this is not the case; their numbers may change dramatically. These changes are known as *population fluctuations*.

There are three basic types of population fluctuations: *cyclic, nonfluctuating and irruptive*. These are illustrated in the following graph.



Types of population fluctuations:
(a) cyclic
(b) nonfluctuating
(c) irruptive

Figure 6 - Population Fluctuations

In the cyclic pattern populations show rather regular increases and decreases in numbers. There are two predominant cycle lengths exhibited by different species. There is a short cycle of three to four years exhibited by animals such as the lemming and meadow vole and a long cycle of 10 years exhibited by organisms such as the snowshoe hare, Canadian lynx, ruffed grouse and chinch bug. Though a number of explanations have been advanced to explain these regular fluctuations, no one explanation seems to be adequate. Much remains to be learned in this area.

In the nonfluctuating pattern, the population tends to remain relatively stable from year to year. There may be increases in some years and decreases in others, depending on how favorable the environment is from year to year. Tree species in a forest would exhibit this pattern.

In the irruptive pattern, the population remains relatively stable over many years, then takes an abrupt increase to the point where it far exceeds the carrying capacity of the environment. This is followed by a crash in numbers. This type of pattern has been exhibited by grasshoppers, locusts, house mice and rats.

As with the other patterns no one single satisfactory explanation of their occurence has been developed. Some populations seem to fluctuate according to one explanation while another appears to fluctuate according to another explanation.

It is important to remember that different populations are affected in different ways by different factors. Consequently it may be that there is no one universally applicable explanation.

E. Age Distribution

Age distribution refers to the proportion of individuals of different ages within the population. For instance, in a growing population, there will be a large percentage of individuals in the younger age groups and relatively few individuals in the older age groups.

In a stable population, the largest group will be the youngest age group with progressively fewer individuals in each succeeding age group. In a declining population, there will be relatively large numbers of individuals in the oldest age groups, with successively smaller groups as one proceeds toward the youngest age group.

Now that we have discussed the characteristics of populations let us fit these populations into the physical environment and see how they interact with one another in ecological systems or ecosystems.

READ

Read sections 41-6 to 41-12, pages 616 to 620. Be sure to read the summary on page 620.

Ecosystems

An ecosystem is any stable environment in which living and non-living things interact, in which nutrients are used over and over again and through which flows the energy that makes life possible. An ecosystem is composed of a **biotic community** and a physical or **abiotic environment**.

The biotic community is all the different species populations that make up the living portion of an ecosystem. Functionally, these populations may be divided into three different groups on the basis of their energy source:

1. Producers - green plants, algae and a few bacteria.
2. Consumers - all animals, most protozoa and a few fungi.
3. Decomposers - many bacteria, most fungi and a few plants.

When grouping organisms on the basis of function, remember that a population may perform more than one function. A crow, for example, will eat live food some of the time and carrion at other times, thus making it a consumer at times and a decomposer at others. Consequently, a population may belong to one or more of the above groups, depending on the role it plays in an ecosystem.

The physical or abiotic environment is the nonliving part of an ecosystem. It is composed of many physical factors often known as abiotic factors which act either independently or in conjunction with one another to influence living organisms. Let us look at each of these factors.

1. **Energy.** Various forms of energy are present in all ecosystems. These include nuclear, electrical, mechanical, chemical and radiant energy. Radiant energy from the sun is received in a broad spectrum of wave lengths. From shortest to longest these are: gamma rays, x-rays, ultraviolet light, visible light, infrared light, microwaves and radio waves.

2. **Light.** The visible portion of radiant energy from the sun and other stars, used by living things as an energy source, and to aid animals in vision.

3. **Atmosphere.** The reservoir of gaseous compounds that envelop the earth. It consists of 78% nitrogen (N_2), 21% oxygen (O_2), 0.03% carbon dioxide (CO_2) and trace amounts of other gases including water vapor.

4. **Wind.** The movement of atmospheric gases due to uneven heating of the atmosphere by radiant energy from the sun.

5. **Water.** A compound consisting of hydrogen and oxygen (H_2O). It covers 70% of the earth's surface and is responsible for the aquatic habitats, both freshwater and marine. It is a major agent in determining which species will be present in an ecosystem and in shaping the topography of terrestrial habitats.

6. **Temperature.** A complex factor dependent on intensity and duration of the radiant energy received each day or on a season-to-season basis. It is often a factor in determining which species will be present in a community.

7. **Soil.** The zone that links life on the surface to the mineral core of the earth. It often consists of a number of layers of parent materials from the underlying bed rock and decomposed matter from dead organisms. It holds water, air and minerals used by plants and acts as an anchoring medium for their roots. Soil is also the habitat of numerous species of microorganisms and a few larger burrowing organisms (e.g. earthworms, ground squirrels).

8. **Geological substrate.** The bedrock underlying soil. It affects the formation of new soil and the drainage of water through the topsoil. It may be exposed as mountains or where glaciation has scraped away the topsoil.

9. **Topography.** The contour of the land. Geological forces have pushed the mountains and continents up from the seas while the forces of erosion, acting through wind and water, pull the continents back into the sea.

10. **Gravity.** The mutual attraction between all masses in the universe. It is the force that pulls all things towards the center of the earth. All living things must respond to gravity in some way (e.g. plant roots grow downwards). It is probably the most constant of all the factors.

11. **Fire.** The combustion of organic compounds. In the terrestrial environment it can effectively destroy many of the populations that make up the biotic community.

12. **Others.** Other abiotic factors include sound, air pressure, water pressure, water currents, etc.

Limiting Factors and Tolerances

To survive and reproduce in an environment, organisms need an assortment of essential materials from the environment. Which specific materials an organism needs depends on the nature of the organism and the conditions under which it is living. If any one substance is available in amounts approaching the minimum amount required by an organism, this substance is most likely to become a **limiting factor** if its scarcity increases. Anything that is essential to an organism and for which there is competition, intraspecific or interspecific, is called a limiting factor of the environment.

The **range of tolerance** of an organism is the range within which a host of environmental factors must be if an organism or species is to survive. The **limits of tolerance** are the maximum and minimum amounts of the factor which the organism can tolerate. Somewhere between these points lies the optimum, the amount of the factor which best suits the needs of the organism.

Some of the factors for which organisms exhibit a range of tolerance are water, temperature, light, minerals and humidity. For example, a species of plant may be able to survive in environments where the yearly rainfall is a minimum of 35 cm to a maximum of 93 cm. These two points represent this species' range of tolerance for this factor. If numerous individuals of the species were subjected to different amounts of rain betwen these two points, it might be found that the optimum (best) conditions for growth might occur when plants received 65 cm of rain a year. Thus, it would be expected that this species would do best in environments that received 65 cm of rain yearly, provided other factors in the environment were not limiting or outside the organism's range of tolerance.

If even one factor is in excess of or below the ranges of tolerance exhibited by an organism, it will not survive in the ecosystem, even though all other factors may be within its range of tolerance. The limits of tolerance are a part of the inherent qualities of organisms, that is, they are as a rule genetically controlled and may vary from population to population even within the same species.

Distribution, Habitat and Niche

The **distribution** of an organism is the geographic location on the earth where an organism is found. **This is sometimes referred to as its geographic range.** Some organisms have very restricted distributions. For instance *Grylloblatta campodeiformis*, a relative of the grasshopper and cricket, is so rare that it has only been found in one area in the Canadian Rockies, south of Banff. Other organisms such as man and the rat have very wide distributions, being found worldwide.

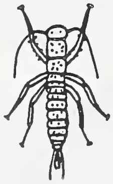


Figure 7 - *Grylloblatta campodeiformis*, length 3 cm

The distribution of plants is most affected by the climate and the soil nutrients available for their growth. The distribution of animals is for the most part affected by the climate and availability of an appropriate food source.

Within any one geographic area may be numerous habitats (e.g. ponds, streams, coniferous forest, deciduous forest etc). Therefore, the geographic distribution of an organism and the habitat cannot be considered identical. The habitat is the type of place (ecosystem) an organism lives. It includes the living as well as non-living aspects of the place. For instance, the habitat of the beaver in Alberta is the waters of small streams, rivers, lakes and ponds. These waters must be surrounded by sufficient deciduous trees such as poplar and willow as these are the food source and construction materials of the beaver.

The **niche** of an organism is the way it lives or its status within a community. The habitat describes the environment where an organism is found. The niche describes how the organism lives within the community, i.e. its role in the community. The role of the organism is a product of its structural adaptations (e.g. the beaver has chisel-like front teeth for cutting trees), and its behavior (e.g. the beaver slaps its tail on the water to warn other beavers of danger).

The niche of an organism includes such things as what the organism does, what its source of energy or food is, which organisms use it as a source of food, its effects on other members of the same species and other species within the community and its effects on the physical environment and vice versa. For example, the beaver cuts down willow and poplar trees and uses the bark of these trees as food. On small streams it will use branches of trees and mud to make a dam that creates a pond deep enough for the beaver to live in.

Beavers also live in natural lakes and ponds or in large rivers. In large rivers home consists of a burrow into the bank from an underwater entrance with an above water living chamber. In lakes, ponds and dammed streams it builds a lodge of mud and branches. The lodge has an underwater entrance and an above water living chamber. The beaver stores food (poplar and willow branches) in the mud at the bottom of its pond, as a source of food during the winter when the pond is frozen over.

The beaver has one mate for life and averages three to four offspring per litter. The offspring are born in June and live with their parents for two years before they are driven off to find a mate and a suitable building site of their own.

The important predators of the beaver are man and the otter. Occasionally a wolverine, wolf, bear, coyote, lynx or cougar may catch a beaver while it is away from water.

This is not a complete description of the beaver's niche but it does give you a reasonably good idea of the organism's role within its community.

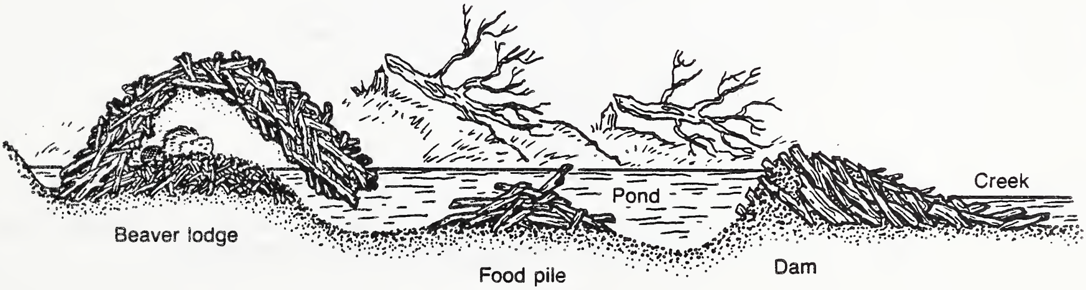


Figure 8 - The beaver's habitat

EXERCISES TO BE SENT FOR CORRECTION

Part One: Multiple Choice

_____ 1. When the range of a species extends beyond the area a population occupies, the population would be

(a) a local population.
(b) highly gregarious.
(c) clumped.
(d) in a state of decline.

_____ 2. When defining a population it is important to state

(a) the number of and type of organism.
(b) the space the population occupies.
(c) the time at which the population exists.
(d) all the above.

_____ 3. The environment in which an organism lives is known as its

(a) niche.
(b) habitat.
(c) biotic community.
(d) nesting site.

_____ 4. The two factors that operate to increase population size are

(a) immigration and emigration.
(b) natality and mortality.
(c) immigration and natality.
(d) emigration and mortality.

_____ 5. The death of a population is known as

(a) mortality.
(b) extinction.
(c) natality.
(d) extermination.

_____ 6. Over a 20-year period there was a slow decline in the density of spruce trees in a forest. This decline was most likely due to

(a) emigration.
(b) immigration.
(c) natality.
(d) mortality.

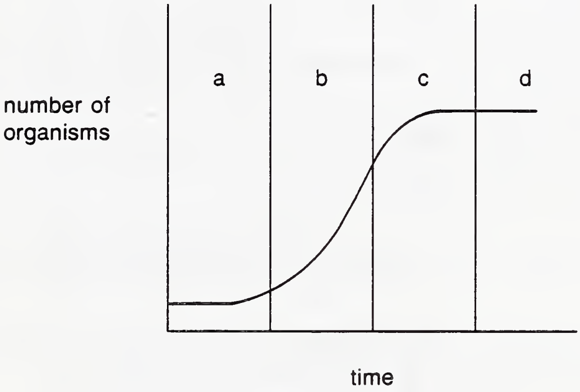
______ 7. In deserts, water would

(a) be a biotic factor.
(b) be a limiting factor.
(c) not be present.
(d) stunt the growth of plants.

______ 8. The number of organisms an environment can support is known as

(a) the carrying capacity of the environment.
(b) the density of the environment.
(c) the biotic potential of the environment.
(d) homeostasis.

The following illustration of an S-shaped growth curve pattern has been divided into four regions labelled a through d. Use the illustration to answer the next six questions.



______ 9. The population exhibits its lowest density at stage

(a) a.
(b) b.
(c) c.
(d) d.

______ 10. The carrying capacity of the population is reached at stage

(a) a.
(b) b.
(c) c.
(d) d.

______ 11. The stage that is closest to the biotic potential of the population occurs at stage

(a) a.
(b) b.
(c) c.
(d) d.

______ 12. Environmental resistance becomes increasingly stronger at stage

(a) a.
(b) b.
(c) c.
(d) d.

______ 13. The population is in homeostasis with its environment in stage

(a) a.
(b) b.
(c) c.
(d) d.

______ 14. The maximum rate of increase occurs at stage

(a) a.
(b) b.
(c) c.
(d) d.

______ 15. A population is maintained at about the same size on a year to year basis because of

(a) natality.
(b) mortality.
(c) niche.
(d) homeostasis.

______ 16. Which of the following is not a characteristic of an individual?

(a) motion
(b) birth
(c) death
(d) density

_____ 17. When the size of a population changes over a period of time this is an example of

(a) rate.
(b) density.
(c) natality.
(d) mortality.

_____ 18. Which of the following is a proper expression of density?

(a) 10 cats per 10 m^2
(b) 0.01 cats per 2 m^3
(c) 1 cat per 5 m^2
(d) 0.1 cats per m^2

_____ 19. If a population existed on an island from which *no* individual were able to leave it would be described as a

(a) closed population.
(b) open population.
(c) local population.
(d) migratory population.

_____ 20. If 48 mice were born into a population of mice over 12 days, the natality rate would be

(a) 48 mice per 12 days.
(b) 0.5 mice per hour.
(c) 4 mice per day.
(d) a mouse every 4 days.

_____ 21. If a population had a natality rate of 0.1 individuals per hour, a mortality rate of 0.1 individuals per hour, an immigration rate of 0.3 individuals per hour and a emigration rate of 0.3 individuals per hour; the population would

(a) increase at a rate of 0.8 individuals per hour.
(b) decrease at a rate of 0.8 individuals per hour.
(c) be increasing in size.
(d) neither increase nor decrease.

______ 22. If you knew the density of a population and the amount of space the population occupied, you could calculate the number of organisms in the population by

(a) multiplying the density by the space occupied.
(b) dividing the number of organisms by the space they occupy.
(c) dividing the space occupied by the density.
(d) multiplying the number of organisms by the space they occupy.

The next 3 questions are based on a population of gophers in a 250-hectare pasture.

Year	Population - Gophers
1880	14
1890	42
1900	73
1910	117
1920	132
1930	115
1940	80
1950	112
1960	106
1970	110

______ 23. What was the approximate *density* per hectare (ha) of the gophers in the pasture in 1930?

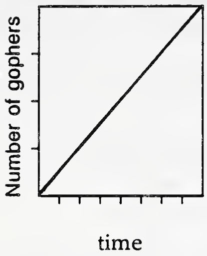
(a) 0.5 per ha
(b) 0.9 per ha
(c) 10 per ha
(d) 115 per ha

______ 24. What was the average *change in number* of the gophers (in whole numbers) from 1880 to 1910?

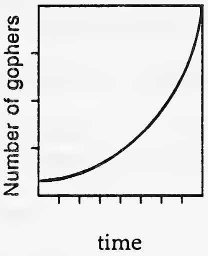
(a) 3 per year
(b) 5 per year
(c) 15 per year
(d) 20 per year

______ 25. Which of the curves shown below is *an approximation* of the growth form of this population of gophers?

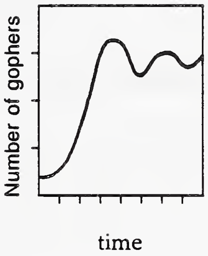
I



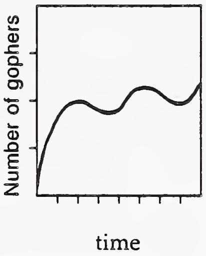
II



III



IV



(a) I
(b) II
(c) III
(d) IV

______ 26. The rate of reproduction among organisms is highly variable because some organisms

(a) reproduce only once in a lifetime while others reproduce many times.
(b) can produce numerous gametes while others produce only a few.
(c) reach sexual maturity much sooner than others.
(d) all the above.

______ 27. Which of the following is *not* a form of environmental resistance?

(a) predation
(b) disease
(c) reproduction
(d) competition

______ 28. When an entire population moves from one location to another this is known as

(a) dispersion.
(b) migration.
(c) immigration.
(d) emigration.

______ 29. Biotic potential is

(a) the rate at which an organism grows.
(b) the rate at which a population grows.
(c) the highest rate of reproduction achievable by a population.
(d) achieved through competition with closely related species.

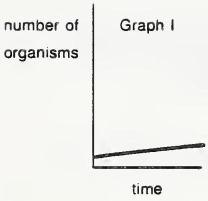
______ 30. An example of passive dispersal is a

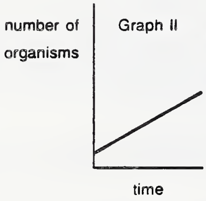
(a) bird flying across a river.
(b) coconut floating in an ocean current.
(c) coyote walking through a forest.
(d) snake crawling through the grass.

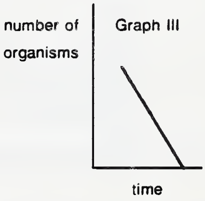
______ 31. The form of distribution exhibited by the majority of populations is

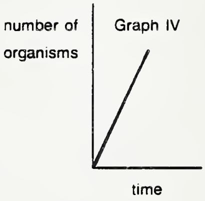
(a) uniform.
(b) random.
(c) clumped.
(d) dense.

______ 32. The graph that illustrates the fastest rate of growth is



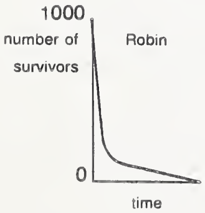


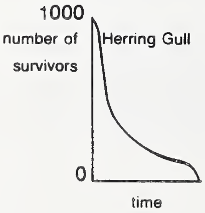


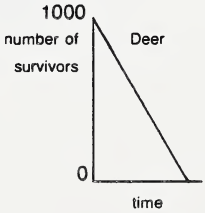


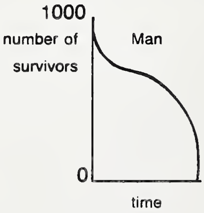
(a) Graph I.
(b) Graph II
(c) Graph III
(d) Graph IV

______ 33. Which organism in the following mortality graphs has the largest percentage of individuals living to old age?









(a) Robin
(b) Herring Gull
(c) Deer
(d) Man

_____ 34. A herd is an example of a

(a) uniform distribution.
(b) random distribution.
(c) clumped distribution.
(d) low density distribution.

_____ 35. A J-shaped growth curve differs from an S-shaped growth curve in that

(a) the J-shaped curve does not at any point reflect the effects of environmental resistance, whereas the S-shaped curve does.
(b) the S-shaped curve more closely reflects the biotic potential of its population than the J-shaped curve does.
(c) it starts off at a high rate of reproduction compared to the population shown in the S-shaped curve.
(d) the population showing the J-shaped curve eventually levels off, whereas the population showing the S-shaped curve continues to increase.

_____ 36. Limiting factors can affect the growth curve of a population by

(a) causing a slowdown in the rate of increase of a population.
(b) increasing the rate at which a population grows.
(c) causing a decrease in population size.
(d) both (a) and (c);
(e) none of the above.

_____ 37. Which of the following factors is least likely to affect the growth form of a population?

(a) gravity
(b) predation
(c) competition
(d) whether a population is open or closed

_____ 38. Population fluctuations broadly fall into the category of being

(a) cyclic.
(b) nonfluctuating.
(c) irruptive.
(d) all the above.

_____ 39. A declining population is characterized by

(a) a disporportionally large group of older individuals and successively smaller groups of younger individuals.
(b) successively larger groups of young individuals.
(c) a very large group of young individuals, a relatively small group of middle aged individuals and a large group of old individuals.
(d) none of the above

______ 40. The two major components that make up an ecosystem are

(a) the biota and the abiotic environment.
(b) producers and consumers.
(c) the abiotic environment and matter.
(d) the biotic community and energy.

______ 41. The biotic community consists of

(a) all the living organisms in an ecosystem.
(b) producers, consumers and decomposers.
(c) a group of populations living in a habitat.
(d) all the above.

______ 42. The majority of the energy used in living systems comes from

(a) plants.
(b) light.
(c) nuclear energy.
(d) electrical energy.

______ 43. Which of the following abiotic factors plays the smallest role in shaping the topography of the earth?

(a) wind
(b) water
(c) gravity
(d) sound

______ 44. The abiotic factor that acts as habitat for the largest number of organisms is

(a) atmosphere.
(b) water.
(c) soil.
(d) geological substrate.

______ 45. The major component of the atmosphere is

(a) nitrogen.
(b) oxygen.
(c) carbon dioxide.
(d) nitrous oxide.

______ 46. The ecological niche of an organism is

(a) its geographic range.
(b) the habitat in which it is found.
(c) the role it plays in an ecosystem.
(d) all the above.

______ 47. The three basic niches that exist in ecosystems are

(a) producers.
(b) consumers.
(c) decomposers.
(d) all the above.

______ 48. If a lynx eats a beaver it would be considered a

(a) producer.
(b) first order consumer.
(c) second order consumer.
(d) decomposer.

______ 49. The group of organisms responsible for recycling dead matter back to its inorganic constituents is the

(a) producers.
(b) first order consumers.
(c) second order consumers.
(d) decomposers.

______ 50. When an organism experiences a shortage of some substance in its environment the substance would be known as

(a) a limiting factor.
(b) an abiotic factor.
(c) a biotic factor.
(d) a nutrient.

______ 51. The part of the world where an organism may be found is its

(a) geographic range.
(b) habitat.
(c) niche.
(d) range of tolerance.

Part Two: Short Answer

1. Seventy-five dandelions were found in a rectangular plot measuring 10m by 25m. Calculate the density of the dandelions in this plot. Show the formula, calculations and units of measure.

2. (a) A rancher has a problem with ground squirrels (gophers) on his range and intends to get rid of them with poison. Each can of poison is effective for killing a maximum of 40 ground squirrels. To know how many cans of poison to buy, he has to find out how many ground squirrels there are in his pasture. He stakes out an area 50m by 50m and after a number of counts determines there are 10 ground squirrels. What is the density of the ground squirrel population in this sample plot? Show all formulae.

(b) The rancher's range (pasture) measures 0.4km by 0.8km. Assuming the density of the ground squirrel population in the sample plot is the same as the rest of the pasture, how many ground squirrels are there in his pasture? Show all calculations, formulae and units.

(c) Using data in (a) and (b), calculate the minimum number of cans of poison the rancher will need to get rid of the gophers.

3. What is the formula used to express the change in density of a population over time?

____

4. Construct a line graph to show the population fluctuations for field mice, based on the number of live mice trapped from a field per 100 traps per night. The mice are live trapped, counted and released so that trapping does not affect the population. They are also free to immigrate or emigrate.

Date	Number of Mice Per 100 Traps Per Night
Sept., 1960	30
Oct., 1960	50
Nov., 1960	42
Dec., 1960	35
Jan., 1961	25
Feb., 1961	19
Mar., 1961	18
Apr., 1961	13
May 1961	12
June 1961	16
July 1961	4
Aug., 1961	18

Review line graph construction in the course Introduction. Construct the graph so that time in months is shown on the horizontal axis and the number of mice is shown along the vertical axis. Select a suitable scale for each axis so that all data is shown on the graph. The graph must be done on the following piece of graph paper and must have a proper title explaining the contents. Label both axes. Once the graph is complete, answer the following questions based on the graph.

(a) What was the average number of mice during this one-year period?

____

(b) Between which two consecutive months did the mice show the largest rate of increase?

____

(c) Between which two consecutive months did the mice show the largest rate of decrease?

____

(d) Would you suspect that this population is open or closed? Why?

____

____

(e) Based on the limited data given, what type of population fluctuation do you think this data represents? What additional data would you need to confirm this?

____

____

____

____

(f) List at least three factors that could be responsible for the fluctuations in this population.

____

____

____

(g) Calculate the rate of change in population numbers per month between October of 1960 and May of 1961. Show all formulae and calculations.

End of Lesson 1

YOUR PERSONAL GUIDE FOR LESSON COMPLETION

In order to ensure that you finish your correspondence course on schedule, without having to send too many lessons at one time, it is important that you devise your own guidelines for lesson submission.

By filling in the blanks below, you can arrive at your own schedule for lesson completion.

1. What is today's date? ________________

2. On what date do you need (or want) to finish the last lesson? ________________

   (If you wish to write the test at the end of the first semester, your last lesson should be sent during the first week of January.

   If you wish to write in June, your last lesson should be sent during the last week in May.)

3. Using a calendar, count the number of weeks between today and the day you plan to finish your lessons.

   Numbers of Weeks: ________________________

4. To convert to the number of days, multiply by 7, since there are 7 days in one week.

   Number of Weeks × 7 = ________________ days

5. Now calculate the number of days you can spend on each lesson.

   $$\frac{\text{Number of Days}}{\text{Number of lessons to do}} = \frac{\text{days}}{\text{lessons}} = \underline{\hspace{4cm}}$$

   Delete any decimal portion in your final result. (For example, if your answer is 6.5 days for each lesson, only allow 6 days rather than 7. If you were to use 7 days for each lesson, your finishing date would be after your target date. By using 6 days, you allow extra time for review.)

6. Now use the number of days per lesson you calculated above to fill in the date each lesson should be completed in the chart on the reverse side. (The easiest way is to count off the days on a calendar.)

Lesson Number	To be completed by:	Completed
	Today's date:	
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Check off each lesson as you complete it. Note whether or not you are meeting your target dates. If you find you are getting too far off schedule, you may have to revise your dates.

Use the chart on the next page to provide a copy for your correspondence teacher.

Name: ____________________ File #: __________

Now copy your schedule into the chart below and send this sheet in with Lesson 1. By having this timetable, your teacher will know how you plan to work on this course.

Lesson Number	To be completed by:	Completed
	Today's date:	
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

QUESTIONNAIRE FOR SCIENCE COURSES

PLEASE COMPLETE THIS FORM AND RETURN IT WITH YOUR FIRST LESSON.

Course: ______________________________

Name: ______________________________ File No.: ______________

Address: ______________________________ Birth Date: ______________

______________________________ Postal Code: ______________

Phone Number: ______________________

1. What were your gradings in the following subjects (if taken)?

Math. Gr. IX ______
Mathematics 10 ______
Mathematics 20 ______
Mathematics 30 ______

Science Gr. IX ______
Biology 10 ______
Biology 20 ______
Biology 30 ______

Chemistry 10 ______
Chemistry 20 ______
Chemistry 30 ______
Physics 10 ______

Physics 20 ______
Physics 30 ______
Physics 22 ______
Physics 32 ______

2. If you are repeating this course, what was your previous mark? ______________________

3. List any special qualifications or handicaps (jobs, illness, disabilities, etc.) which may influence your progress in this course.

____

4. List any other subjects you are studying by correspondence instruction.

____

5. Why are you taking this course? (For matriculation, for diploma, for general interest, etc.) Explain.

____

6. What school are you attending, if any? ______________________________

7. If you took this course previously, where did you carry out the laboratory work? Explain.

____

____

8. What laboratory arrangement have you made for this year?

____

____

9. Do you plan to purchase a laboratory kit? ______________________________

10. Will you have the use of a microscope (for biology students)? ______________________

Sci. Gen. - 3 - 85

Name: ______________________________ File No.: ______________

1					A			
2					B			
3					C			
4					D			
5					E			
6					F			
7					G			
8					H			
9					I			
10					J			
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
Exam.								

LESSON RECORD FORM

2230 Biology 20
Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ______

Time Spent on Lesson ______

(If label is missing or incorrect)

File Number ______

Lesson Number ______

FOR SCHOOL USE ONLY

Assigned Teacher: ______

Lesson Grading: ______

Additional Grading E/R/P Code: ______

Mark: ______

Graded by: ______

Assignment Code: ______

Date Lesson Received: ______

Lesson Recorded ______

Student's Questions and Comments

Apply Lesson Label Here

Name ______

Address ______

______

______

Postal Code ______

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

______
Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

INTERACTIONS

The Ecosystem

In Lesson 1 you learned that an ecosystem is any part of the earth (area or volume) in which living organisms and nonliving (abiotic) substances interact and through which materials are cycled due to the flow of energy. In Lesson 2 you will continue your study of ecosystems by looking specifically at:

- How energy enters and moves through an ecosystem.
- How organisms interact with one another.
- How materials are cycled through an ecosystem.

READ

Turn to page 623 of your text and read sections 42-1 to 42-5. Note that the arrows in Fig. 42-2 and 42-3 are pointed in the wrong direction. They should be pointed opposite the direction shown to properly reflect the flow of energy and matter. Once you have read these sections of the text, return to these notes and continue reading.

Matter and energy are the foundations for the structure and functioning of all ecosystems. The biotic and abiotic components of all ecosystems are composed of matter. The interactions that take place between all the components are fuelled by energy. Now take a closer look at energy and matter and their roles within an ecosystem.

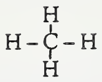
Matter

Matter is anything that occupies space and has mass. Your pencil, this paper, the family pet; all consist of matter. Matter is made up of approximately 100 different elements. **Elements** are substances that cannot be broken down or decomposed into simpler substances by any chemical or physical means. Oxygen (O) and hydrogen (H) are examples of elements. Each element has its own unique properties.

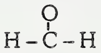
Elements have the ability to combine chemically with one another to form compounds. A **compound** is two or more elements that are chemically combined in definite proportions. Water (H_2O) is a compound of the elements hydrogen and oxygen combined in the ratio of two hydrogen atoms to one oxygen atom. (Atoms are the smallest part of an element that can exist.) The only way water or any other compound can be broken apart is by chemical change.

Compounds can be divided into two groups, organic compounds and inorganic compounds. **Organic compounds** contain carbon atoms linked to hydrogen atoms. Atoms of other elements such as nitrogen or oxygen can also be present.

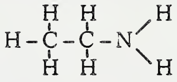
Figure 1: Some examples of organic compounds



CH_4 Methane



CH_2O Formaldehyde



$C_2H_5NH_2$ ethyl amine

Note that compounds such as carbon dioxide (CO_2), carbon monoxide (CO) and carbonates such as calcium carbonate ($CaCO_3$) are not considered organic compounds because the carbon atom is not linked with hydrogen atoms. What makes organic compounds of particular importance in living systems is the fact that the carbon atoms may be linked in long chains or rings to form organic compounds such as carbohydrates, proteins and fats; basically the compounds that make up living matter.

Inorganic compounds are all compounds other than those containing linked carbon and hydrogen atoms. As far as living organisms are concerned, the most important inorganic compound is water (H_2O). Water makes up at least 85 percent by weight of all living cells. Other important inorganic compounds are sodium chloride (NaCl) and carbon dioxide (CO_2).

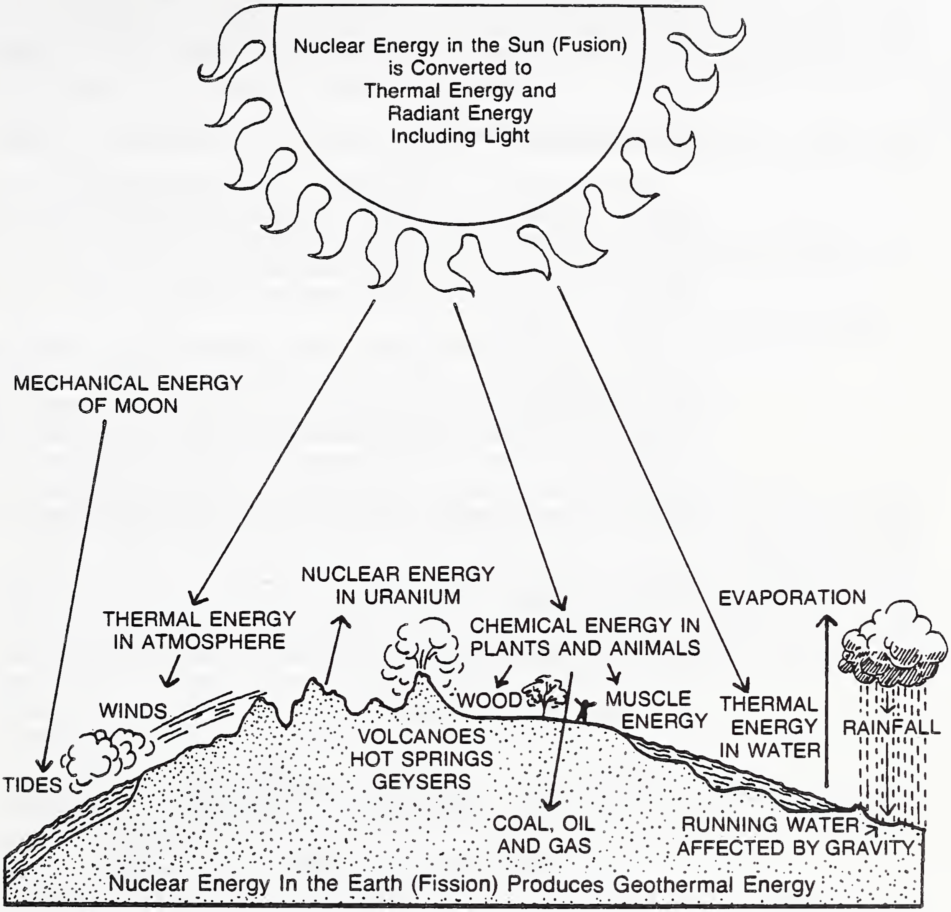
Of the 106 elements that occur on earth, only about 30 are used by living things for their growth and sustenance. Oxygen, carbon, hydrogen and nitrogen are the most important, appearing as pure elements such as oxygen (O_2) or compounds such as water, salt, protein, fat and carbohydrates. These four elements make up over 95 percent of the total weight of every living thing.

Most important is the fact that all the matter that makes up living things comes from the earth. The supply is finite, meaning that it is limited to the quantity on earth. Consequently, it must be used over and over again, or it would all be used up. The matter making up living things circulates from living things to nonliving things over and over. This circulation is known as a cycle. Later on in this lesson you will take an indepth look at the cycle of oxygen, carbon, nitrogen and water.

Energy

Energy can be defined as the ability to do work or cause change. There are many kinds of energy; chemical energy in food and gasoline, electrical energy from hydroelectric generating stations, radiant energy from the sun, the nuclear energy of uranium, the thermal energy of heat, and the mechanical energy of motion. Energy in its various forms is responsible for all the changes that occur about us because it can be converted from one form to another.

Figure 2: Energy On Earth


Nuclear Energy in the Sun (Fusion) is Converted to Thermal Energy and Radiant Energy Including Light
MECHANICAL ENERGY OF MOON
NUCLEAR ENERGY IN URANIUM
THERMAL ENERGY IN ATMOSPHERE
CHEMICAL ENERGY IN PLANTS AND ANIMALS
EVAPORATION
WINDS
WOOD
MUSCLE ENERGY
THERMAL ENERGY IN WATER
RAINFALL
TIDES
VOLCANOES HOT SPRINGS GEYSERS
COAL, OIL AND GAS
RUNNING WATER AFFECTED BY GRAVITY
Nuclear Energy In the Earth (Fission) Produces Geothermal Energy

All activities require that energy in one form or another must be present. So it is in living systems. The activities of all livings things such as breathing, walking, growing, and reproducing all require energy. For consumers, the energy comes from the food they eat. Foods such as potatoes, bread, apples, and meats all contain energy that consumers can use for activity. The energy in food is in the form of chemical energy. This energy exists in the bonds that hold together the atoms making up the food.

Some consumers, such as cats, eat other consumers, such as birds and mice, to provide the energy they need for their activities. The birds and mice may eat other consumers, such as grasshoppers and earthworms, or they might eat seeds from plants. The energy in the food for all consumers can eventually be traced to producers such as green plants and algae. Since producers do not eat anything, they must be getting their energy by some other means. Indeed they do. Plants are able to convert light energy into chemical energy through the process of photosynthesis. The chemical energy can then be used by the plants themselves or by other organisms that eat them.

Thus, it is clear that the chemical energy used by all plants and animals comes from the light energy of the sun. Since living things use energy in their activities, a continuous supply must come from the sun if life is to go on. The continuous one-way flow of energy through living systems is in sharp contrast to the recycling of matter.

Food Chains and Pyramids

Although matter and energy have been discussed separately, in nature they function together. Through photosynthesis, producers take carbon dioxide and water from their surroundings and, in the presence of chlorophyll and light energy, combine this matter into simple sugars (chemical energy) which the producer can use for growth or activity. Thus matter and energy are intimately combined in what we know as food.

Once the food has been produced, it is passed from one organism to the next in a sequence known as a **food chain**. All food chains must begin with a producer because producers are the only organisms capable of converting light energy into chemical energy. The first-order consumers, also known as herbivores, eat the producers. The second-order consumers, known as carnivores, eat the first-order consumers. There may be several more consumer levels though the total number of levels does not usually exceed five. The successive levels in a chain are known as trophic levels. A typical terrestrially based food chain is illustrated below.

Figure 3: A Food Chain

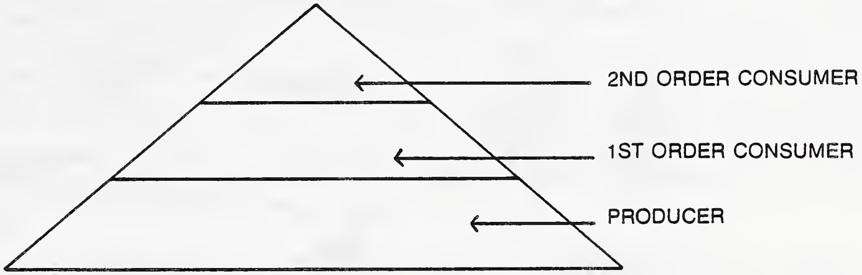
First Trophic Level	Second Trophic Level	Third Trophic Level	Fourth Trophic Level	Fifth Trophic Level
Producer	1st order consumer	2nd order consumer	3rd order consumer	4th order consumer
Grass ➡	Grasshopper ➡	Frog ➡	Garter snake ➡	Hawk

Note that a food chain always starts with a producer and that the arrows indicate the direction of the flow of matter and energy. Producers take compounds from the environment that contain no useful energy (CO_2 + H_2O) and through photosynthesis use light from the sun to convert these inorganic compounds into the organic compound, glucose. Oxygen is a waste product of the process. The glucose can be converted to starch for long-term storage or to other compounds (proteins, oils, cellulose) that the producer can use for growth. Some of the glucose is also used in cellular respiration to provide energy for the cellular functions of the producer. Heat energy is also given off whenever respiration occurs.

Of all the energy that arrives on earth as light from the sun only about one per cent is trapped and stored as chemical energy by the producers. Part of the reason for this is that photosynthesis is not a terribly efficient process. Producers do not cover the entire surface of the earth and they are often dormant for much of the year.

At each trophic level (producer, herbivore, carnivore) much of the energy available from food is used up in activity or lost as heat. Consequently, only 10 to 20 per cent of the energy can be harvested and used at the next level. As a result, there is a stepwise decrease in the energy available as one proceeds from one trophic level to the next. This relationship can be illustrated by an **energy** or **ecological pyramid**.

Figure 4: An Energy or Ecological Pyramid Showing Energy Stored In Each Trophic Level



In all food chains, matter is returned to the environment through respiration, as bodily wastes, or through the decomposition of dead organisms. Any organic compounds remaining in bodily wastes or dead matter are converted back to their inorganic constituents by the respiratory activities of decomposer organisms. Thus, matter constantly moves through the biotic community back to the abiotic environment, where it can be picked up again by the producers. A continuous supply of light energy must be present if the producers are to provide the food to sustain the consumers in a food chain. Energy is not recycled; it follows a one-way path.

Food Webs

Food chains are fine for tracing the flow of matter and energy through a particular set of organisms but are not effective in showing the overall series of feeding relationships that exist in a community.

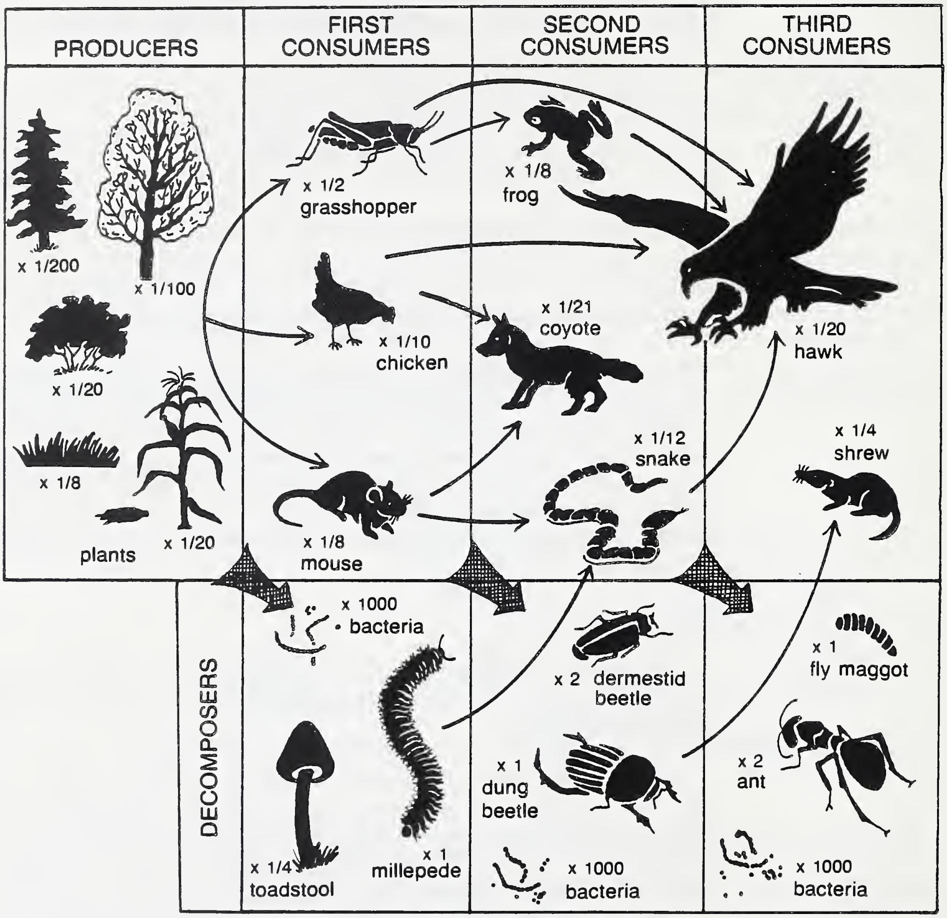
Furthermore, food chains do not take into account that a particular organism normally eats a variety of things, thus occupying more than one trophic level within the community. Black bears, skunks and racoons, for instance, are omnivorous. That is, they eat both plants and animals. They will eat a variety of vegetation, insects, fish, small mammals, and any carrion (decaying flesh) as part of their diets. They occupy the niche of a herbivore, carnivore, or scavenger, as the opportunity arises. These animals can occupy any consumer trophic level, depending on the food they happen to be eating at the time.

Not all species are this adaptable. Some may only occupy two trophic levels during their life cycle. For instance, frogs as tadpoles are herbivores but upon maturing as adults become insectivorous. Other species, mostly herbivores, never switch trophic levels but may change the type of producers they consume in response to the availability of a particular food item.

It is plain that it is best not to try to make a neat classification of organisms by trophic level. Feeding relationships are best represented by a food web, a diagrammatic representation of the feeding relationships in a community. Any particular route through the web becomes a food chain.

Note that the web shown in Fig. 42-2 on page 624 of the text has the arrows pointing in the wrong direction. They should point in the opposite direction if the flow of matter and energy is to be represented correctly.

Figure 5: A Food Web Showing the Different Trophic Levels



Interactions Among Organisms

READ

Turn to page 627 of your text and read the remainder of Chapter 42, sections 42-6 to 42-10. Don't forget the summary on page 631. Next, return to these notes and continue reading.

Ecological interactions are the relationships that develop between organisms in a biotic community. Interactions are often classified according to the effects that members of one species have on the numbers of a second species. If an increase in population size for one species causes an increase in the growth rate of the second species population, the relationship can be described as being positive (+). If an increase in population size of a species has the opposite effect and causes a decrease in the growth rate of the second species population, the relationship can be described as being negative (−). When one species population has no effect on another, the relationship is neutral (0).

Interactions between two species can be represented by a pairing of the three signs, +, −, and 0. In a (+, +) interaction, each species benefits from the presence of the other. This type of interaction is known as **mutualism** or **protocooperation**. In **mutualism** neither species can survive without the presence of the other. In **protocooperation**, both species benefit from interactions with each other but they can survive without each other.

In the (−, −) interaction each species harms the other. This type of interaction is known as competition. **Competition** is rivalry between species for a specific resource, such as food space, water, air, or light. Trees in a forest compete for light; the fastest growing trees receiving the most light, shade out the slower growing species.

The (+, −) interaction includes both **predation** and **parasitism**. In **predation**, the predator species benefits by consuming individuals of another species, the prey. The predator species receives food as a benefit. The prey species is harmed by the death of individual members. Generally, predation is taken to include only animals consuming other animals, not plants.

In **parasitism**, organisms of one species obtain food by living on or within the bodies of organisms of another species. The parasite receives its food as a benefit. The host is harmed by having some of the food it ingests or some of its tissues consumed, though it is not usually seriously harmed or killed in the process. Parasitism includes interactions between both plants and animals. Some plants, such as the mistletoe, are parasites on trees. Certain fungi are able to parasitize animals (eg. ringworm). Animals also parasitize other animals (eg. tapeworms). In parasitism, the benefited species is always much smaller than the harmed species.

In the (+, 0) interaction, one species is benefited and the other is unaffected. This is called **commensalism**. Examples of commensalism are mentioned in the text, page 629.

All the previously mentioned interactions can be considered examples of symbiosis. **Symbiosis** is any relationship in which two species interact with each other in any way. In some cases both species benefit (mutualism and protocooperation). In other cases only one species benefits and the other is either harmed (predation and parasitism) or not affected (commensalism). Only in competition are both species negatively affected. Though the text lists only parasitism, commensalism, protocooperation, and mutualism as examples of symbiosis, many other texts also include predation and competition.

Ecological Cycles

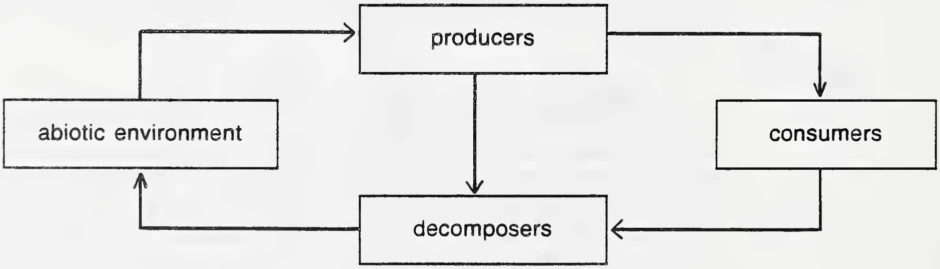
In all ecosystems energy enters the biotic community through the producers. It is passed along the food chains, where it is used for one activity or another, and eventually dissipates as heat. Consequently, energy must constantly be replenished in an ecosystem. With respect to matter however, certain important chemical substances are used over and over as they alternate between the living and nonliving parts of an ecosystem. The more or less circular paths of chemical elements passing back and forth between the biotic and the abiotic community are known as **ecological** or **biogeochemical cycles**.

The inorganic chemical substances used by living organisms are found in the water, air and soil that make up the abiotic environment. The producers combine water and carbon dioxide through photosynthesis to produce the food necessary for themselves and all other living things.

Producers and consumers also take in other inorganic substances such as water, oxygen,and calcium, using them, along with organic compounds from food, in the life processes that sustain them. The matter that is passed from consumer to consumer in a food chain is eventually released back to the environment, either excreted as waste, or through death and decay. Decomposer organisms use any energy stored in dead organic matter. Through respiration they break these compounds down into their inorganic constituents; primarily carbon dioxide and water.

Any inorganic substances (water, salts) associated with the dead matter simply dissipate unchanged back into the abiotic environment. Thus the cycle is completed. Chemical substances are taken from the abiotic environment and used by living organisms for all their life processes before they are eventually returned to the environment. The generalized cycle of matter can be represented as follows:

Figure 6: Generalized cycle of materials in an ecosystem



As was mentioned earlier, living organisms use some 30 elements. Though all these elements follow the generalized cycle indicated above, they can be divided into two groups, those that have gaseous-type cycles and those that have sedimentary-type cycles.

The substances that have **gaseous-type cycles** are oxygen, carbon dioxide, nitrogen, and water. All of these substances exist primarily as liquids on the earth's surface or as gases in the atmosphere. This large gaseous and liquid pool is important in the continuous flow of these substances between the organic and inorganic states.

All other substances, such as calcium, phosphorus, potassium, sulphur, sodium, chlorine, magnesium, iron, have a **sedimentary-type cycle**. Their cycles follow the patterns of erosion, sedimentation, mountain building, and volcanic activity.

READ

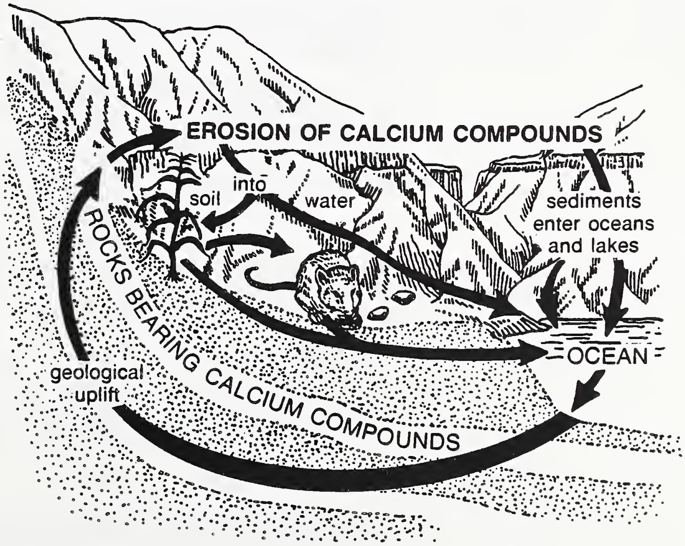
Turn to Chapter 43, page 633 and read sections 43-1, -2, -3, -5, and -8, which describe in detail the gaseous-type cycles of oxygen, carbon, nitrogen, and water. You do not have to read sections 43-4, -6, -7 or -9 as we will be covering this material in a later lesson. Don't forget to study figures 43-1, to 43-4. Finish reading the notes in this lesson before attempting the lesson exercises.

The text does not describe or illustrate a sedimentary-type cycle so we will look at the calcium cycle, which is typical.

Compounds of calcium are relatively common in the rocks of the earth (e.g limestone, $CaCO_3$). Some of these compounds are partially soluble in water. Consequently, organisms pick up calcium in the water they drink. Also, plants are able to obtain calcium compounds from the soil. The calcium in the plants is then passed on to consumers through food chains. At any stage in the chain, the calcium may be returned to the soil or water by the activities of decomposers.

Organisms such as clams and oysters use calcium to build shells. The bones of animals contain calcium. When organisms die, their shells or bones can accumulate at the bottom of oceans, lakes and ponds. If enough of this material accumulates over a long period, it may eventually become rock. This sedimentary rock may later be thrust upwards to become hills and mountains. The forces of erosion will then start to wear the mountains away, exposing the calcium-containing rocks. Rains will again dissolve some of the calcium-containing compounds and start them on their way through streams and rivers back to the ocean in a never ending cycle.

Figure 7: A Sedimentary-Type Cycle: The Calcium Cycle


EROSION OF CALCIUM COMPOUNDS
into
soil
water
sediments enter oceans and lakes
ROCKS BEARING CALCIUM COMPOUNDS
OCEAN
geological uplift

EXERCISES TO BE SENT FOR CORRECTION

Part One: Multiple Choice

______ 1. When a bee pollinates a flower, the flower is dependent on the bee for

(a) food.
(b) shelter.
(c) reproduction.
(d) protection.

______ 2. When organisms of one species directly affect organisms of another species, this could best be described as

(a) an interaction.
(b) a reaction.
(c) predation.
(d) competition.

______ 3. All organisms are able to make use of

(a) radiant energy.
(b) heat.
(c) inorganic chemical energy.
(d) organic chemical energy.

______ 4. Which of the following describes the route taken by energy through living systems?

(a) light energy → chemical energy → heat
(b) chemical energy → heat → light energy
(c) heat → light energy → chemical energy
(d) chemical energy → heat → light energy

Use the following key to judge the statements in questions 5 through 8. Match the correct letter from the key to each statement.

Key:
A. producers
B. consumers
C. both producers and consumers
D. neither producers nor consumers

______ 5. use heat as a source of energy.

______ 6. make chemical energy using light energy.

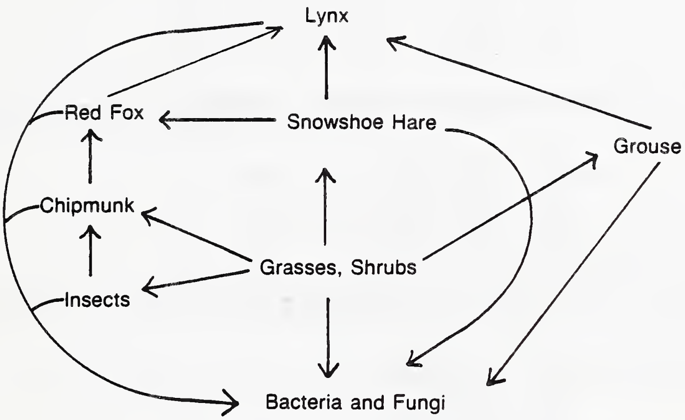
______ 7. use sugar as a source of energy.

______ 8. require chemical energy from external sources.

_____ 9. In a four-level food chain, the least amount of energy is available at the

(a) first trophic level.
(b) second trophic level.
(c) third trophic level.
(d) fourth trophic level.

Use the following diagram to answer the next 6 questions.



_____ 10. The diagram above illustrates

(a) an energy pyramid.
(b) a food web.
(c) a carbon cycle.
(d) a food chain.

_____ 11. Which organism is an omnivore?

(a) snowshoe hare
(b) grouse
(c) insect
(d) chipmunk

_____ 12. Which organism is a decomposer?

(a) chipmunk
(b) grass
(c) bacteria
(d) grouse

______ 13. Which organism is most important in providing energy for the other organisms?

(a) grass
(b) hare
(c) insects
(d) chipmunk

______ 14. In an energy pyramid, the least energy would be stored at the level represented by the

(a) fox.
(b) lynx.
(c) hare.
(d) grouse.

______ 15. The sequence: grass → chipmunk → fox → lynx represents

(a) a food web.
(b) competition.
(c) protocooperation.
(d) a food chain.

______ 16. In any particular place, the living organisms and the nonliving environment operate together as

(a) a population.
(b) a species.
(c) an ecosystem.
(d) a community.

______ 17. Anything that occupies space and has mass is known as

(a) energy.
(b) matter.
(c) entropy.
(d) work.

______ 18. Any compound that consists of carbon atoms linked with hydrogen atoms is

(a) an inorganic compound.
(b) an organic compound.
(c) radioactive.
(d) poisonous.

______ 19. The four most common elements found in living things are

(a) carbon, calcium, oxygen and nitrogen.
(b) carbon, oxygen, hydrogen and nitrogen.
(c) carbon, oxygen, silicon and hydrogen.
(d) carbon, oxygen, water and nitrogen.

_____ 20. In all organisms the majority of the body consists of

(a) protein.
(b) calcium.
(c) carbohydrates.
(d) water.

_____ 21. If energy loss from one trophic level to the next is between 80 and 90 per cent, how much of the original energy would be left after it passed from the first trophic level to the third trophic level?

(a) 80 to 90 per cent
(b) 10 to 20 per cent
(c) 8 to 9 per cent
(d) 1 to 4 per cent

_____ 22. When describing the role of matter and energy in ecosystems, it would be correct to say that

(a) both are cycled over and over between the biotic community and abiotic community.
(b) both have a one-way flow through a biotic community.
(c) matter is constantly recycled but energy is constantly required.
(d) energy will be used over and over to move matter through the biotic community.

_____ 23. All food chains must begin with a producer because

(a) consumers can only eat plants.
(b) producers are the only organisms capable of producing food from light.
(c) consumers can only get inorganic compounds from producers.
(d) producers provide all the matter used by consumers.

_____ 24. From energy pyramids we know that

(a) the largest amount of energy is stored at the top of the pyramid.
(b) carnivores have more energy available to them than herbivores.
(c) energy losses from level to level limit the length of food chains.
(d) there is very little energy available from organisms at the bottom of the pyramid.

_____ 25. The feeding relationships that exists between the different populations that make up a biotic community are best described as a

(a) grazing food chain.
(b) detritus food chain.
(c) ecological pyramid.
(d) food web.

_____ 26. Any relationship in which two species interact with each other in any way is known as

(a) symbiosis.
(b) mutualism.
(c) protocooperation.
(d) predation.

_____ 27. An interaction between species populations in which one population is benefited and the other is harmed is known as

(a) predation.
(b) parasitism.
(c) both (a) and (b).
(d) obligate symbiosis.

_____ 28. An non-photosynthetic plant living on another plant would probably be

(a) an epiphyte.
(b) a liana.
(c) a parasite.
(d) a lichen.

_____ 29. The organisms primarily responsible for returning elements and compounds in the biotic community back to the abiotic community are the

(a) producers.
(b) herbivores.
(c) carnivores.
(d) decomposers.

_____ 30. The oxygen that is present in the atmosphere is

(a) a result of the process of respiration.
(b) present as a compound.
(c) a result of the process of photosynthesis.
(d) used in the process of photosynthesis.

_____ 31. Carbon dioxide is added to the atmosphere as a result of

(a) cellular respiration.
(b) decay.
(c) combustion.
(d) all the above.

_____ 32. If carbon dioxide were removed from the atmosphere, which organisms would first suffer negative biological effects?

(a) producers
(b) herbivores
(c) carnivores
(d) decomposers

_____ 33. Which is the most likely original source of the energy found in oil and coal?

(a) sunlight
(b) green plants
(c) dinosaurs
(d) decomposers

______ 34. For plants to use nitrogen, it must be in the form of

(a) ammonia.
(b) atmospheric nitrogen.
(c) nitrates.
(d) amino acids.

______ 35. Water enters the atmosphere through the process of

(a) evaporation.
(b) sublimation.
(c) transpiration.
(d) all the above.

______ 36. The element that has a sedimentary-type cycle is

(a) oxygen.
(b) nitrogen.
(c) magnesium.
(d) carbon.

Part Two: Matching

1. The key below lists the different types of interactions that occur between species in an ecosystem. Use the key to classify the interactions that occur between species in the list. Place the letter of the correct answer in the space to the left.

Key:				
	A.	Competition	D.	Commensalism
	B.	Parasitism	E.	Protocooperation
	C.	Predation	F.	Mutualism

______ 1. humans and rats

______ 2. humans and dogs

______ 3. Rhizobium bacteria and alfalfa

______ 4. fleas and cats

______ 5. a bird nesting in a tree

______ 6. mycorrhizae

______ 7. humans and horses

______ 8. coyotes and foxes

______ 9. squirrels and hazelnut trees

______ 10. tapeworms and whitefish

______ 11. a burr clinging to a rabbit's fur

______ 12. grizzly bear and salmon

2. Match the items in the left column with the items on the right. Write the letter of the correct answer in the space on the left.

______	1.	first trophic level	A.	symbiosis
______	2.	moisture escaping a plant leaf	B.	omnivore
______	3.	an organic compound	C.	detritus
______	4.	a product of photosynthesis	D.	carbon dioxide
______	5.	dead organic matter	E.	nitrogen fixers
______	6.	eats plants and animals	F.	transpiration
______	7.	circular movement of compounds between the biota and physical environment	G.	producers
______	8.	interactions between species	H.	oxygen
______	9.	a product of respiration	I.	biogeochemical cycle
______	10.	blue green algae	J.	methane

Part Three: Written Response

1. Explain how a detritus food chain differs from a grazing food chain.

2. Explain why a lichen is an example of mutualism.

3. Design a food web based on the organisms that exist in your community. Include as many trophic levels as you can. Domestic and/or native species can be included.

4. List the ways in which calcium can enter the biotic community.

5. What role, if any, does the biotic community play in the movement of water from the liquid to the gaseous state?

END OF LESSON 2

LESSON RECORD FORM

2230 Biology 20
Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ____________________

Time Spent on Lesson ____________________

(If label is missing
or incorrect)

File Number ____________________

Lesson Number ____________

FOR SCHOOL USE ONLY

Assigned Teacher: ________

Lesson Grading: ______

Additional Grading E/R/P Code: ______

Mark: ________

Graded by: ________

Assignment Code: _____

Date Lesson Received: ____________________

Lesson Recorded _____

Student's Questions and Comments

Apply Lesson Label Here

Name
Address

Postal Code

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____
Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

SUCCESSION IN TERRESTRIAL ECOSYSTEMS

Introduction

In Lesson 3 you will look at ecological succession—what it is and how it takes place. As well, you will look at the major biomes found around the world. Finally, you will study in detail the biomes found in the province of Alberta.

READ

Read Chapter 44, pages 643 - 651 of your text, then return to these notes and continue reading. Note on p. 649, there is an error in the text describing the photographs. There are no glaciers in Northern Saskatchewan. They are, however, found in the mountains of Western Canada.

Succession

Succession is the progressive change in composition of a community of organisms from the initial colonization of a disturbed or bare area towards a largely unchanging group of populations known as the climax community. If you think about this definition, a number of questions or concerns may come to mind:

- Why is there a change in the species composition over a period of time?
- What are the first organisms present?
- Is there a specific order in which the species change or is the change random?
- If there were no organisms present in the area in the first place, how did they get there and how will the succeeding species populations get there?
- What is the rate of change at which this process proceeds?
- Why does the climax community tend to be self-perpetuating when previous communities were temporary?
- Since most areas have plant and animal life, what is the origin of these lifeless or disturbed zones?

Now take a look at the answers to some of these questions.

Habitat Formation

How do barren areas come about? The geological forces that built and modified the continents are responsible for the production and exposure of many locations where there is no life. Upthrusting of the continental crust has resulted in the formation of mountains. Volcanic action in the oceans has pushed magma to the surface to form islands. The erosional forces of glaciers, wind and water have all exposed areas devoid of life. When succession starts in an area devoid of organisms or an area unchanged by organisms, this is known as **primary succession.**

Succession also takes place in **disturbed areas**, that is areas that supported a biotic community that has since been destroyed or reduced by one force or another. Natural disasters such as fires, floods, volcanic activity, glaciation, erosion, landslides, droughts and violent storms can temporarily denude an area or cause death to many of the species populations in an area. Disturbances can also occur due to the effects of living organisms, in particular man. Activities such as farming, mining, forestry, road building, construction of towns and cities, and grazing of domestic animals have led to the disturbance or destruction of many communities. When succession starts from this point it is known as **secondary succession** because some of the organisms or the effects of these organisms may still be present, i.e. as organic enrichment of the soil.

Dispersal

Now that we know how barren and disturbed areas come about, let us turn our attention to how organisms are able to move into these areas. In areas only marginally disturbed, many species will remain or be nearby to revegetate the denuded areas by the spread of their seeds and spores. In areas where denudation is more complete or where organisms have never existed, colonization must take place by **dispersal**, the process by which a population moves into previously unoccupied territory, thus expanding its **geographic range** (the area of the world in which a species is found).

Organisms that are **motile** (able to move) can move from place to place and thus expand their ranges. The dispersal of these organisms can be halted by **barriers**. The means of dispersal for a species will determine what barriers it may face. For terrestrial organisms, large bodies of water may act as barriers. For aquatic organisms, a large body of land may be a barrier.

Barriers can be large, like mountain ranges, deserts and oceans; or as small as a fence or a stream. Barriers can be physiological. Many plants, for instance, cannot survive in soils lacking the mineral calcium. Consequently, calcium-deficient soils would be a barrier. For organisms adapted to the grasslands, a forest may form an ecological barrier. Some organisms even exhibit behavioral barriers by remaining in very restricted areas even though a similar habitat may exist right next to their current range. This is true for many of the birds of the Amazon Basin rainforests.

Organisms attached to their substrate (the surface on which they live) or those lacking motility are posed with special problems. How are they able to *disperse*? At some stage in their life cycle they must package themselves or parts of themselves (**disseminules**) into forms suitable for transport by outside agents. Among plants the most common disseminules are seeds, fruits and spores. Some animals produce eggs, cysts and zoospores.

The transport of individuals or disseminules to new habitats can take place by water dispersal, wind dispersal, self dispersal, animal dispersal, and dispersal by man. Many plants disperse their seeds by shooting them away from the parent plant when the seed pod opens. The caragana and pea vine use this type of self dispersal. Many plants and animals rely on wind dispersal. The young of many spiders are able to balloon many miles through the air on a thread of silk. The dandelion, goat's beard, Manitoba maple, ash, birch and spruce, all rely on some adaptation of their seeds, be it a wing or parachute-like structure, to carry these disseminules through the wind to some location away from the parent plant. All fungi and ferns rely on wind to spread their spores.

Many organisms are spread by ocean currents. The nut of the coconut palm floats in ocean currents and spreads to new volcanic islands as they arise. Marine organisms such as kelp, diatoms, algae, corals, sea worms, clams, sea urchins and crabs rely on ocean currents to spread their disseminules. Birds spread the seeds of various fruits (blueberry, mountain ash, etc.) from place to place when the seeds are eliminated from the digestive tract of these birds. Burs (a type of seed) are spread by attachment to the hair or fur of animals. Man is perhaps the largest disseminator of other species, whether accidentally or on purpose. The spread of the rabbit and prickly pear cactus to Australia, and the sparrow, rat and starling to North America are all examples of dispersal by man.

Once an organism or its disseminule has been dispersed to a new habitat, it must establish itself, survive and reproduce, if the species is to extend its geographic range. Whether an organism is able to survive and reproduce to establish a new population depends on a number of factors. For producers, the climate and soil must be suitable for the establishment of the new population. Most often the probability of the new habitat being favorable is greatest the nearer the parent population. For sexually reproducing organisms, whether plants or animals, both sexes must be dispersed to the new location if a new population is to be produced. For consumers, the presence of an adequate food source and shelter are some of the prerequisites for the establishment of a new population.

Seres

The time, from initial colonization of a barren or disturbed area to the time the climax community develops is known as a **sere**. Any one community within a sere is known as a **seral stage**.

The first group of plants to invade a barren or disturbed area is known as the **pioneer plant**. Once the producers are in place they provide the resources necessary for invasion by the consumers. The organisms that form the **primary community** depend on what producers and consumers are available in surrounding areas.

Without being species specific, it is possible to describe the general events that take place during succession. As succession starts, the pioneer plants invade the new area. At first there may only be a few primary producers but as they increase in number they have an increasing effect on the abiotic environment, in particular the soil. Chemical and physical reactions on their substrate can produce such changes as the breakdown of rock into smaller particles, changes in the pH and water-holding capacity of the soil due to the accumulation of dead plant matter, increase in humidity, the binding of loose sand particles etc. As the soil is modified, generally becoming more fertile, the way is paved for other species of plants to invade the new area.

As the organisms in each seral stage change the environment, they create conditions suitable to other species. Changes in the producer species usually result in changes in the consumer species. Each new species competes with earlier ones for resources such as water, nutrients, food and space, and will eventually displace the very species that provided the initial favorable conditions for its growth.

And so it goes. The community gradually changes as earlier species are replaced by later species from one seral stage to the next until the climax community is eventually arrived at. The driving force that propels succession is the ability of certain species to make chemical and physical changes in their environment, making it suitable for other species to compete for the niches available in the ecosystem.

The following data summarizes many of the important aspects of the process of succession:

1. Changes in species composition of the area being colonized occurs most rapidly during the early stages of a sere and slows as the climax is approached.

2. The number of species, the complexity of food webs and the number of available niches all increase as succession proceeds.

3. The species composition in the early seral stages of primary and secondary succession can differ markedly even in the same climatic region. However, as the sere proceeds, later stages will bear a progressively closer resemblance to one another as the climax is approached.

4. The total weight of organic matter (living and non-living) increases in early seral stages because the amount of organic matter produced by plants is greater than that consumed as food. In later seral stages, including the climax community, the activities of producers and consumers become balanced, with production matching to consumption.

5. As the increase in number of species occurs in a sere, there is a corresponding increase in the number of larger organisms in the community (eg. trees replace shrubs, shrubs replace herbs.)

6. The climax community theoretically perpetuates itself indefinitely unless disturbed. The climax is maintained because each species reproduces and maintains a stable number of individuals. Species of the climax community are able to repel or exclude potential competitors under the conditions in the community which they themselves maintain.

7. The rate at which succession takes place is highly variable. As a rule primary succession takes much longer than secondary succession, especially on bare rock where soil formation may take a thousand years or more. The climate, the nature of the substrate, and the extent of disturbance are all factors in determining the rate of succession.

The Climax Community

When no disturbances occur, the climax community becomes the end product of succession. The climax will exhibit greater stability and permanence than all seral stages preceeding it.

The species that will form the climax are determined by the climate. Where the climate is moist, some type of forest will develop. The type of forest (tropical rainforest to taiga) is determined by interactions between moisture and temperature. In drier regions; chapparal, savanna, grasslands and deserts will form the climax. These major terrestrial communities are known as **biomes.** A biome is a major, regional, ecological unit with a characteristic biotic community (the climax) determined by the climate. Within a biome may be smaller ecosystems in one stage of succession or another, but these areas are all considered part of the biome as they all lead to the climax; the ecosystem determined by the climate.

READ

Now that we have studied succession and discovered it is responsible for producing the major biomes on this planet, let us take a closer look at these biomes and their characteristics. Turn to Chapter 47, "The Terrestrial Habitat," and read pages 671 - 681, then return to these notes and continue reading.

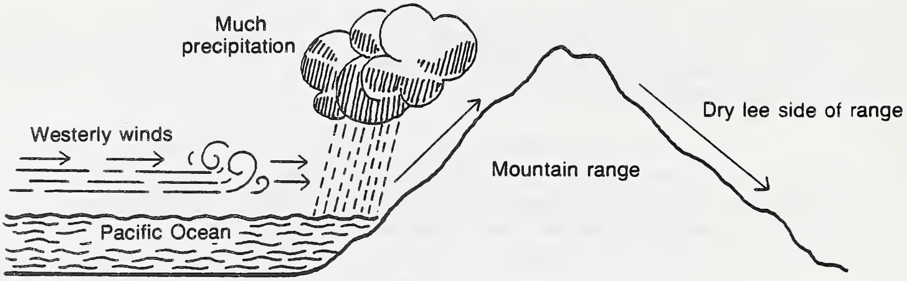
Biomes of Canada

The biota of a community is determined by the climate, the geographic features and the soils of a region. The climate of Canada is a product of the way geographic and topographic features affect the general weather patterns of the world. Geographically, Canada is located in the northern hemisphere starting at 42°N latitude in Southern Ontario and extending north to the North Pole. This northerly position gives us seasons that are warm in summer and cold in winter. The warmest climates are found in the south while the coldest are in the north. Due to the rotation of the earth and a number of other complex factors, winds in Canada are primarily from the west though these can be modified by cold air moving down from the north or warm air moving up from the south.

The temperature of the west coast is moderated by the effects of the Pacific Ocean. The ocean is warmer than the land in winter and colder than the land in summer. Consequently water temperatures rarely fall below freezing and summer temperatures seldom rise above 28° C. The moist westerly winds off the Pacific are temporarily slowed as they encounter the mountains along the west coast. As the air rises to climb over the windward (west side) of the Coastal Range it is cooled, causing it to condense and fall as rain at lower elevations and snow at higher elevations.

Over 200 cm of precipitation each year falls along the west side of the Coastal Range to produce the lush rainforest typical of the west coast. As the winds cross the highest point in the Coastal Range they start to descend in altitude and increase in temperature. Consequently they start to pick up moisture rather than give it up. This is known as the rain shadow effect. Thus the lee side (east side) of the Coastal Range is much drier than the windward side and has a correspondingly different type of vegetation. Once past the Coastal Range, the same thing happens each time these westerly winds encounter the next mountain range to the east.

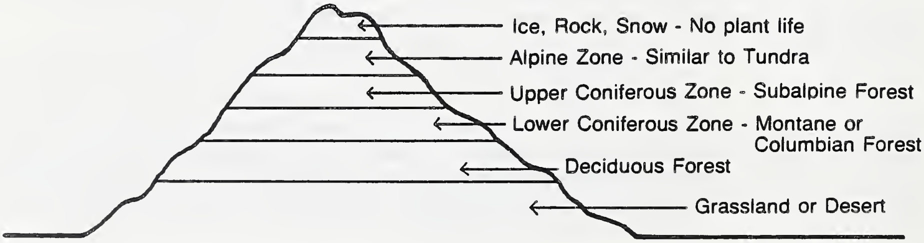
Figure 1: Mountain Ranges and Precipitation



Also complicating the picture is the fact that temperature decreases 1°C for every 150-metre increase in elevation. Consequently, one does move through a number of vegetation zones as one moves up the side of a mountain. At the base of a mountain and in the valleys we might find desert-like or dry grassland conditions, depending on the amount of available precipitation. Such conditions exist in the Kamloops area of B.C. and in Southern Alberta west of Pincher Creek. Above this, one could expect to find deciduous forest, predominantly aspen poplar. Above this come the different types of coniferous forest with Montane or Columbian forest at lower levels and the Subalpine Forest above. These three types of coniferous forest are composed of different species because of differences in precipitation, light and soils. The final life zone above the coniferous forest is the alpine zone. This zone above the tree-line has a variety of low growing plants adapted to very harsh conditions. Only ice, rock and snow are found above, as temperatures are too severe to support any plant life.

Figure 2: Altitudinal Vegetation Zones

Note: not all zones may be present depending on mountain height and local climatic conditions.


Ice, Rock, Snow - No plant life
Alpine Zone - Similar to Tundra
Upper Coniferous Zone - Subalpine Forest
Lower Coniferous Zone - Montane or Columbian Forest
Deciduous Forest
Grassland or Desert

As you can see, Canada's mountain environment is a product of the complex interactions between factors such as latitude, altitude, prevailing winds, precipitation, topography and soils. As a result, there is a corresponding diversity of vegetation types, most within close proximity of one another. The diversity of vegetation zones found in the mountains has led to this region being sometimes described as **complex zonation**.

Once east of the Rocky Mountains, a whole new series of factors influence the climate and thus biota across the rest of Canada. Winds still prevail from the west but have been for the most part stripped of their moisture while crossing the mountains so precipitation is generally low. Temperatures are cold in winter and vary from cool to hot in the summer depending on how far north you go.

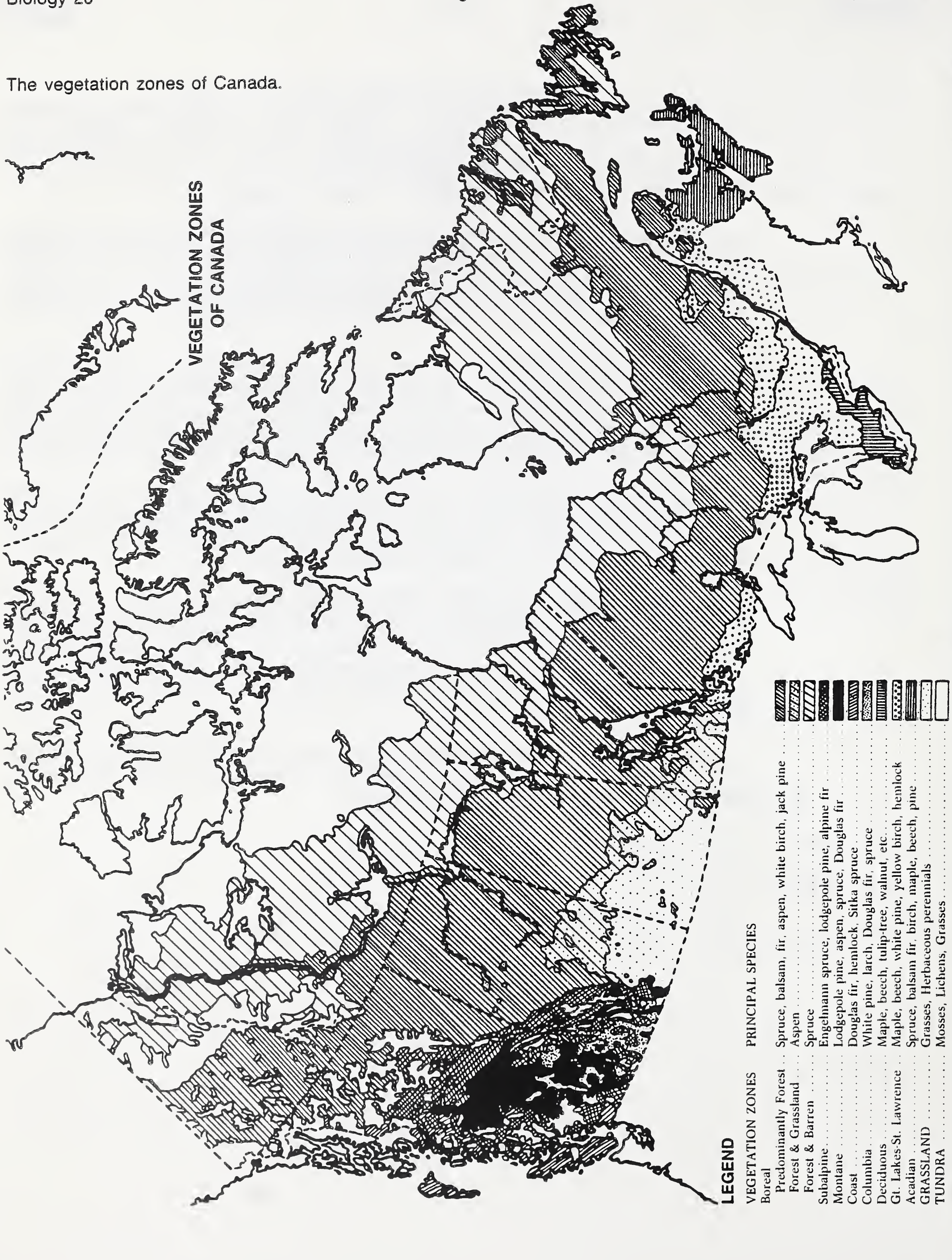
Biomes west of the Rockies tend to run in broad east-west bands. In the far north is the tundra, a vast treeless plain with vegetation in many ways similar to the alpine zone found in the mountains. Below the tundra is the taiga, also known as the boreal forest. This broad east-west band of coniferous forest extends southward from the tree line in the North West Territories to the northern half of all the provinces from Alberta to Newfoundland.

Below the taiga one finds Aspen Parkland of Alberta, Saskatchewan and Manitoba. The Aspen Parkland is a mixture of grassland and poplar bluffs and reflects a warmer, somewhat drier climate than the taiga to the north but not as hot and dry as the grasslands of Southern Alberta, Saskatchewan and the western corner of Manitoba.

In Ontario, Quebec and New Brunswick one finds a mixed-woods forest (coniferous-deciduous), known as the Great Lake St. Lawrence forest. Only in Southern Ontario, between Lake Huron and Lake Erie, does one find true deciduous forest in Canada. The last two types of forest are the product of a warm climate and an adequate source of moisture, the result of the warm humid air currents from the Gulf of Mexico and the moisture provided by the Great Lakes.

In the eastern half of New Brunswick and all of Nova Scotia and Prince Edward Island, we find a different type of mixed-woods forest known as the Acadian Forest, the climax of the maritime climate of the east coast of Canada.

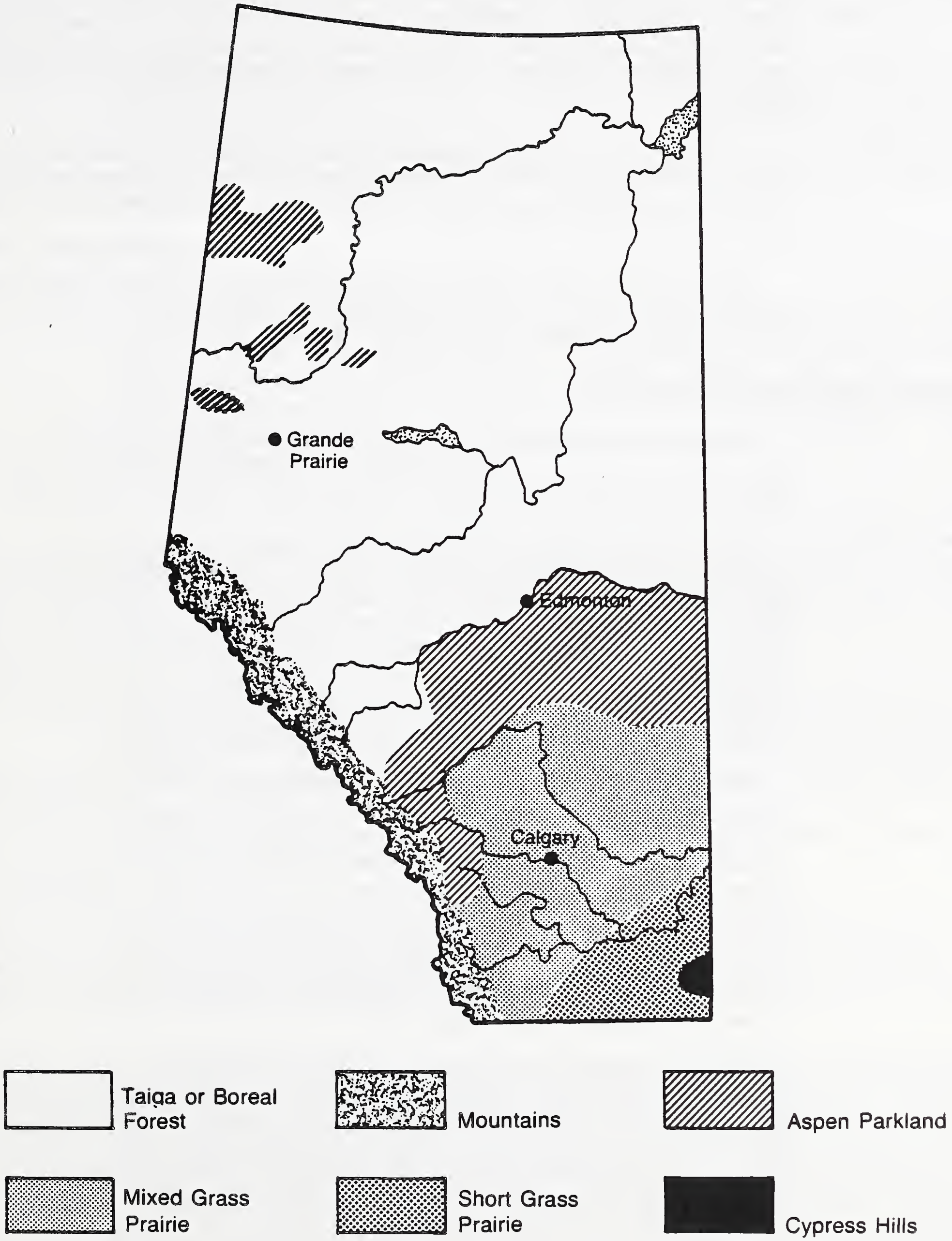
The vegetation zones of Canada.



LEGEND

VEGETATION ZONES	PRINCIPAL SPECIES	
Boreal		
Predominantly Forest	Spruce, balsam, fir, aspen, white birch, jack pine	▨
Forest & Grassland	Aspen	▨
Forest & Barren	Spruce	▨
Subalpine	Engelmann spruce, lodgepole pine, alpine fir	▩
Montane	Lodgepole pine, aspen, spruce, Douglas fir	▩
Coast	Douglas fir, hemlock, Sitka spruce	■
Columbia	White pine, larch, Douglas fir, spruce	▨
Deciduous	Maple, beech, tulip-tree, walnut, etc.	▩
Gt. Lakes-St. Lawrence	Maple, beech, white pine, yellow birch, hemlock	▤
Acadian	Spruce, balsam fir, birch, maple, beech, pine	▥
GRASSLAND	Grasses, Herbaceous perennials	⠿
TUNDRA	Mosses, Lichens, Grasses	□

Alberta's Biomes and Ecotones



Biomes of Alberta

Alberta has a variety of biomes, each consisting of a characteristic climax community. In the northern half of the province we find the boreal forest, by far the largest of Alberta's biomes. To the south of the taiga lies the aspen parkland, a mixture of poplar groves and grassland. The parkland is an **ecotone**, a transition zone between two major biomes, in this case the taiga and grasslands. Isolated pockets of aspen parkland can also be found in the Grande Prairie, Peace River areas as well as in the foothills between the Rockies and the grasslands.

To the south of the aspen parkland lie the prairies or grasslands consisting of two distinct zones, the mixed grass prairies and the short grass prairies. In the southeast corner of the province lie the Cypress Hills, an area of coniferous forest similar to that found in the foothills approximately 250 km to the west.

The Rocky Mountains along the western border of the province comprise an area of complex zonation, that is, a variety of biomes develop in response to localized conditions. You will now take a closer look at these biomes.

Producers of the Taiga or Boreal Forest

The taiga (also known as boreal forest) forms the largest biome in Alberta, covering the entire northern half of the province. The predominant tree species are the white and black spruce. However, spruce are not the only type of tree found in the this forest.

The forest can range from almost pure stands of aspen and balsam poplar, as is common on the southern border of the boreal forest, to the pure stands of white spruce found further north. In fact, it is quite common for the forest to be a mixture of tree types with varying proportions of species, including white and black spruce, balsam and alpine fir, jack pine, lodgepole pine, tamarack, aspen and balsam poplar and white birch. The composition of the forest in any location will be a product of the local conditions. Black spruce and tamarack are the main species in muskeg sites. Jack pine predominates on dry ridges and in sandy locations. Willow and alder will be found bordering streams and lakes.

The species composition of the forest **understory** (plants living below the dominant tree species) is largely influenced by the type of trees that form the uppermost layer of a forest or the **canopy**. In taiga where aspen and balsam poplar predominate, a great deal of light and precipitation are able to reach the forest floor because these trees produce a relatively thin layer of foliage that only lasts from spring to fall. Consequently the understory consists of a number of layers of shrubs and herbs. Taller shrubs include low bush cranberry, saskatoon, dogwood, raspberry, hazelnut, and buffalo-berry. Lower shrubs include rose, currants, honeysuckle, buckbrush, and snowberry. Low growing shrubs and herbs include sarsaparilla, lungwort, asters, vetch, twinflower, strawberry, bunchberry, bishop's cap, horsetails, wintergreen and bedstraw.

The species composition of the predominantly aspen mixed-wood forest is highly diversified. By comparison, the species composition of the understory of the predominantly spruce mixed-wood forest is quite impoverished, a direct result of the nature of the canopy produced by the spruce trees. Spruce trees have a pyramidal shape with layer upon layer of overlapping branches extending from near the ground to as high as 25 metres on taller trees. The needle leaves of the spruce densely cover the branches and are thus able to absorb a great deal of light as well as hold a lot of water when it rains.

Due to the depth of the canopy and the nature of the needles and branches, very little light or rain is able to reach the floor of the forest. Consequently, only a few species of plants are able to survive. The feather mosses seem to do well under these conditions and usually form a thick carpet on the floor of the forest. They are adapted to the low light conditions and simply become dormant when there is too little water for photosynthesis to take place.

Other species that may be found on the spruce forest floor include green alder, low bush cranberry, prickly rose, bunch berry, twin-flower, horsetails, wintergreen, cowberry, lily-of-the-valley and northern commandra. In boreal forest, where a mixture of coniferous and deciduous species form the canopy, the understory will be composed of species from both types of forest plus some that are unique to the intermediate condition of sunlight and moisture this type of forest produces.

Consumers of the Boreal Forest

Where there are plants there is food. Let us now look at the consumers that make up the boreal forest. Among the small consumers that attack the trees of this forest are numerous species of insects. Leaf miners consume the mesophyll layer of cells between the two epidermal layers that make up the leaves of trees. Wood borers chew long winding tunnels in the stems of trees. Defoliators such as the tent caterpillar and sawfly consume the leaves directly off the trees. Finally, there are the bark beetles that feed on the live phloem, cambium and xylem tissue just beneath the bark.

There are numerous herbivorous mammals. Smaller forms include the red squirrel, flying squirrel, chipmunk, woodchuk, beaver, muskrat, mouse, vole, porcupine and snowshoe (varying) hare. Each of these species occupies its own unique niche and specializes in harvesting particular plants or plant parts. For instance, the red squirrel is adept at eating the cones of conifers but will also consume nuts, strawberries, currants, mushrooms, insects and their larvae, and sometimes even birds eggs.

The muskrat builds its lodges and bank burrows in freshwater marshes, the marshy areas of lakes and in slow moving streams. Its favorite food is cattails but it also eats bulrushes, horsetails, pond weeds, sedges, wild rice and willows. When normal foods become scarce, muskrats will eat fish, frogs and clams, though these are normally not part of their diet.

The larger herbivores include the elk, moose, mule deer, and wood bison. Barren ground caribou migrate into the north-east corner of this region in winter.

Truly omnivorous species include the skunk, black bear and grizzly. The grizzly, though much feared by man, is for the most part a plant eater, consuming different types of roots, grasses, berries and nuts appropriate to the season. It will also eat the dead carcasses of old or winter-killed animals; the newborn of deer, moose, elk; ground squirrels, ants, fish and any other organisms it might capture.

The carnivorous mammals of the taiga include the coyote, red fox, wolf, lynx, marten, fisher, wolverine, weasel, mink and otter. Wolves are known to prey on larger species such as elk, moose, deer and caribou which they hunt in packs. They will also take smaller species; mice, ground squirrels and hares when the opportunity presents itself. Varying hares, mice, voles and birds form a large part of the food supply for smaller carnivores such as the coyote, lynx, fox, marten, fisher, mink and wolverine. The fisher is particularly adept at killing the porcupine by flipping it on its back before killing it. The otter is predatory on a variety of fish and small animals. The list of predator-prey relationships that exist in the taiga is extensive. The examples given here are only an introduction to the complex food webs that exist in this biome.

Numerous species of birds also frequent the taiga. Most of these are only summer residents, migrating back to the south with the return of winter. Only 33 of the 300-odd species that reside in Alberta in the summer, winter over in the taiga. Among them are the chickadee, great horned owl, snowy owl, willow ptarmigan and raven.

Spring heralds the arrival of a great variety of species of birds for the purpose of feeding and breeding, including the ducks—the mallard, blue winged teal, bufflehead, canvasback, pintail, and redhead among them. Other shore and water-associated species include geese, swans, loons, grebes, herons, cranes, sandpipers, blackbirds, phalaropes, gulls, terns, and kingfishers. Among these is the rare whooping crane, a bird on the verge of extinction. There are less than 100 left, and their only remaining breeding site is in Wood Buffalo National Park in Northern Alberta.

Insectivorous birds include night hawks, warblers, flycatchers, swallows, woodpeckers, phoebes, nuthatches, wrens and a variety of other species. Birds which feed predominantly on the seeds, berries and buds of plants include the waxwings, grosbeaks, finches, sparrows and crossbills. Birds which eat a variety of plant and animal matter include the crow, raven, chickadee, and robin.

There are also a number of predatory birds in the taiga. Hawks such as the goshawk, sharp-shinned and red-tailed hawk, eat a variety of animals including squirrels, rabbits, mice and voles. Eagles are represented by the golden and bald eagle. There are also many species of owls which feed at night and roost by day.

Though not complete, this overview of the biota of the taiga does give an indication of the complex relationships and interactions that take place among the species of this biome.

Mountains (Complex Zonation)

The mountains along the western border of Alberta cover much less area than other biomes in the province. In many respects, the mountain biota resembles a southern extension of the boreal forest and tundra biomes because of the many common species of plants and animals they share.

The white spruce is one of the most common trees at elevations below 2000 m. Above this, the Englemann spruce and alpine fir tend to replace it. Lodgepole pine is also abundant and after fire, acts as a successional species. If the burnt areas remain undisturbed long enough the pine will again be displaced by the spruce. Douglas fir occurs in isolated patches. Alpine larch is commonly found just below the timber line.

Aspen poplar is common in stands at lower elevations and if conditions are right, will grow instead of pine after a fire. Beaver are found near aspen groves, where they may use all the aspen before moving on. Junipers, bearberry, Indian paintbrush, various orchids, twinflowers, fireweed, clematis, cinquefoil and asters are among the smaller plants often prominent in different parts of the mountains.

At elevations above the timberline, where soil has formed, can be found the alpine meadows of the alpine tundra zone. The plants in this zone are all woody shrubs or herbs that grow very low or flat against the ground. The shrubbery consists of heathers and alpine willow. Numerous species of herbaceous flowering plants make the alpine slopes a most colorful place during the short summer. Some common ones include grasses, cinquefoils, anemone, alum root, three-flowered avens, lousewort, alpine forget-me-not, mountain avens, saxifrage, and snow lilies. Other plants include lichens, mosses and sedges. Many of these species are the same as those of the northern tundra but some are exclusive to this zone.

Many animals of the mountain regions are the same as those of the boreal forest, including the black bear, grizzly, elk, coyote, beaver, lynx, moose, wolverine, wolf, fisher, marten, red squirrel, chipmunk, beaver and mule deer. Exclusive to the mountains are the Columbian and golden-mantled ground squirrel, marmot, mountain goat, Rocky Mountain bighorn sheep, pika, blue grouse and white-tailed ptarmigan.

The cougar and wolf are the mountain predators of large herbivores such as elk, deer and sheep. By keeping the number of herbivores down, they protect the forests and meadows from overgrazing and overbrowsing. If herbivores become too numerous, they can outstrip their food supply causing many to die of starvation or disease. Thus the predators play an important role in maintaining the balance of nature in the mountains.

The pika or rock rabbit inhabits the scree slopes high in the alpine tundra. It is a short-eared relative of the rabbit and hare. This shy animal, colored much like the rocks it lives in, is seen only by the keen-eyed. To find it, listen for its shrill whistle or hunt among the rocks for the piles of hay it makes for its winter food supply.

Birds you are likely to see in the mountains include Barrow's goldeneye, harlequin duck, golden eagle, blue grouse, white-tailed ptarmigan, Clark's nutcracker, Canada jay, water ouzel and raven. Each of these birds has a specific niche and will be found in different habitats throughout the mountains. For instance Barrow's goldeneye and the harlequin duck can be found on mountain lakes. Clark's nutcracker, blue grouse and Canada jay are common residents of the coniferous forest, though each relies on different food supplies. Numerous other small birds are found throughout the mountain regions. The common loon, the osprey and the spruce grouse are birds of both the boreal forest and the mountains.

Grasslands or Prairies

The grassland biome of Alberta is commonly referred to as the prairie biome. There are two distinct zones; the mixed-grass prairie and the short-grass prairie. The short-grass prairie is found in the arid, brown soil zone of Southeastern Alberta. The mixed-grass prairie is located north and west of the short-grass prairie in the dark brown soil zone.

Grama grass, spear grass, quack grass and fescue are prominent grasses of the region. The distribution of the prairie grasses is largely conditioned by the climate, and both affect the nature of the soil. The type of plants that become established often depends on the type of soil. How the soil then develops depends on the plants. Both reflect climatic conditions. For instance, brown soils receive little moisture and bear relatively scant plant growth. Because of the scant plant growth, little organic matter is available to the soil. Rapid evaporation due to high temperatures and strong winds extracts water rapidly from the unprotected soil. This concentrates minerals very highly, thus making for poor plant growth. Conditions are somewhat better in the dark brown soil zone.

Across the prairie there is a large and distinctive fauna (animal life). Characteristic birds include Swainson's hawk, the American goldfinch, and the flocks of ducks, geese, cranes and other birds that migrate through the region each spring and fall. The black and white lark bunting is restricted to the prairies. The sloughs and lakes of the prairies support many shorebirds including the willet, the American avocet and Wilson's phalarope.

Well-known to all plains dwellers in Alberta are the two introduced game birds, the ring-necked pheasant and the Hungarian partridge. The pheasant, originally Asiatic, was long ago introduced into Europe, and first brought to Alberta about 1908. From a shaky early start, it is now well-established and very popular. The Hungarian partridge, also brought in about 1908, established itself quickly and has long been a prime game bird in Alberta.

Many of the mammals of the plains, such as coyotes and white-tailed deer, extend into the mountains and boreal forest. Distinctive plains animals are the plains bison (now found only in reserves), and the pronghorn antelope. The pronghorn is the only species of its family and is only found on the North American prairies. Both sexes of the pronghorn have horns, which like the cow's horns, slip over bony cores. Unlike the cow, the pronghorn sheds the horn sheath every year. Pronghorns are among the fastest mammals, having been clocked at between 100 and 110 km/h over short distances. With keen senses, great speed and protective coloration, they are well adapted for life on the prairies.

Badgers are prairie animals which live almost exclusively on ground squirrels. The jackrabbit and cottontail are prairie dwellers, along with the ground squirrels.

The shortgrass prairie is located in the southeast corner of the province in the Milk River - Medicine Hat - Manyberries area where it is hot and very dry. It is this region where the pronghorn antelope, the cottontail rabbit, the lark bunting, and the prairie falcon are most commonly found. This northern extension of the vast semi-desert regions of the United States is the only place in Alberta where the spadefoot toad, the shorthorned lizard (horned toad), the western rattlesnake (poisonous), the gopher snake and the hognosed snake, are found. Other characteristic animals are the kangaroo rat and the sage grouse, a bird on the verge of extinction in Alberta.

Several unique invertebrates also are found in the region. They include the sun spider and scorpion. Black widow spiders, a poisonous species, are also present. Blue, grama and spear grass are abundant and characteristic of the region. Among the plants restricted to the area are the yucca or soapweed, greasewood, and the flowering quillwort. Cacti are present as well.

Cypress Hills (Complex Zonation)

The Cypress Hills form the highest elevated plateau in the plains of Western Canada. They are located in the semi-arid southeastern corner of the province. Below the soil layer a cap of hard conglomerate has prevented the erosion of softer underlying shales and limestone. Compared to Medicine Hat in the surrounding shortgrass area, the Cypress Hills receives around 13 cm more rainfall a year and is on average a few degrees cooler.

To a biologist, the Cypress Hills are of interest because they support a rich flora and fauna with a strong representation of Rocky Mountain species. Lodgepole pine and white spruce blanket the northern-facing hillsides and a small area of aspen parkland occupies the top of the plateau. The dusky flycatcher, white-crowned sparrow, Oregon junco, and Audubon's warbler are examples of birds which breed here as well as in the Rocky Mountain region.

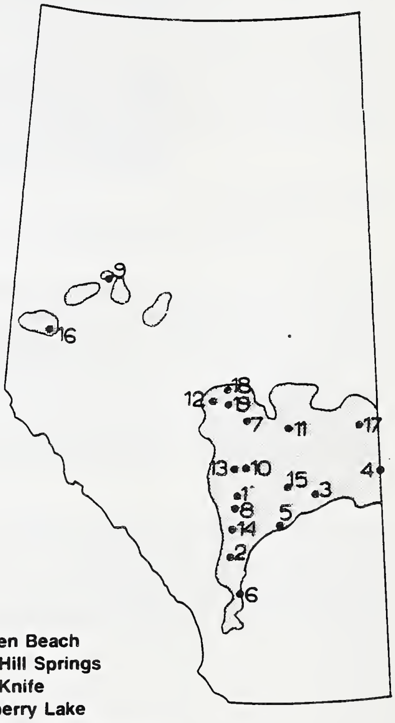
Aspen Parkland

Read the pamphlet the *Aspen Parkland* reprinted in this lesson courtesy of Alberta Recreation, Parks and Wildlife. Note that the aspen parkland is an ecotone, that is, a transition zone between the taiga and grassland, two major biomes in Alberta.

If you wish to know more about the biome in which you live, I suggest you get the book *Alberta, A Natural History*, W.G. Hardy (Editor), Hurtig Publishing, Edmonton, 1967. It gives an excellent account of the climate, weather patterns, geological history, plants and animals found in the various biomes in the province. The book is available in all school and public libraries, so it is not hard to obtain.

THE PARKLAND REGION

This brochure portrays some of the animals, plants and landscapes which make up Alberta's Aspen Parkland. It is a natural region familiar to most Albertans and many visitors as it surrounds Alberta's capital city Edmonton and stretches east to the provincial border and south along the outer edge of the foothills to Calgary. Isolated pockets of Aspen Parkland are also found in the Peace River country. The map below details the extent of the Parkland region and shows the location of Alberta Provincial Parks situated in the Aspen Parkland.



1. **Aspen Beach**
2. **Big Hill Springs**
3. **Big Knife**
4. **Dillberry Lake**
5. **Dry Island Buffalo Jump**
6. **Fish Creek**
7. **Hasse Lake**
8. **Jarvis Bay**
9. **Lac Cardinal**
10. **Ma-Me-O Beach**
11. **Miquelon**
12. **Pembina River**
13. **Pigeon Lake**
14. **Red Lodge**
15. **Rochon Sands**
16. **Saskatoon Island**
17. **Vermilion**
18. **Thunder Lake**
19. **Wabamun Lake**

THE PARKLAND STORY

An Introduction

Alberta is composed of several different natural regions; regions defined by their characteristic association of plants and animals. This is the story of the Aspen Parkland region and the part it plays in the natural history of Alberta.

Transition, the struggle for supremacy, and change are all important chapters in the Aspen Parkland story. But there is much more to learn about the interaction and interdependence of all its inhabitants in their many and varied forms. Hopefully, this introduction to the natural history of the Aspen Parkland will aid you in your own personal observations of the Parkland, and help you to enjoy your experiences in one of the Alberta Provincial Parks in the Aspen Parkland.

Transition and Struggle

The landscape of the Aspen Parkland is a combination of rolling hills and flat plains formed during the last glacial retreat. It is also an area of transition between the spruce and aspen mixed boreal forests of the north and the great grasslands to the south. In central Alberta, the mixed boreal gives way slowly to aspen forests while pockets of grassland are found among the aspen. As one moves south, patches of grassland become more evident and aspen forests gradually diminish to separate groves until finally, the grasses dominate the landscape of southern Alberta and aspen are found only in depressions and protected sites.

The Aspen Parkland is a diverse, dynamic natural area. Life, especially for the plants, is one of struggle and continual change. The mixed boreal forest in the north and the grasslands in the south compete constantly with the aspen forests in the Parkland. Climate, fires, animal activity and the natures of the plants themselves, all play an important part in this struggle.

The Aspen Clone

The predominant tree in the aspen forest is the **Trembling Aspen**. It is identified by its long, slender, greenish-grey trunk marked by black scars and by its small, broadly oval, quivering leaves. The leaves flutter in the gentlest breath of wind because the long leaf stems are thin and flattened. The aspen tree's slim profile, quivering foliage and scarred trunk often give it a fragile appearance, however, looks are deceiving in this case for the aspen is a very hardy plant which has developed an ingenious method of ensuring its survival.

Every aspen ultimately grows from a tiny seed blown to a suitable site. If the seed germinates and grows into a tree, the tree's roots will send up shoots called suckers, which in turn can grow into trees and put out their own suckers. A grove of trees all growing by suckers from one parent tree is called an **aspen clone**. Because they are really only interconnected parts of a single plant, the trees of a clone all look alike, come into leaf at the same time, develop the same fall colours and drop their leaves together. Individual clones often stand out in the spring when all the trees of one may be out in leaf, while all the trees of another clone are still in bud. An aspen clone often has a rounded profile with the oldest and tallest trees in the centre, the youngest and shortest trees at the edge. Young clones may occupy only a few square yards while older ones may cover several acres or an entire hillside.

Fields of Grass

Rough Fescue is the characteristic grass of the Aspen Parkland. When ungrazed, it is often called "bunchgrass" because it can grow into dense tussocks. Fescue shares its habitat with other grasses, wildflowers and shrubs and together they make up the grasslands plant community. Where grasslands existed for a long time, they produced deep, rich soils. Today, Rough Fescue grasslands exist only in remote, uncultivated areas where grazing has been minimal. Plants more tolerant of heavy grazing, and cultivated crops, have replaced the fescue in many places so that today's grasslands only resemble those of a century ago.

The Struggle for Supremacy

Burnt over areas, ground disturbed by animals and the shrubby border where aspen grove meets grassland, have been the main battlegrounds for the struggle between aspen and grassland.

The sucker growth at the edge of the aspen clone continually invades the open grassland and in doing so, the young aspen filter the sunlight and help retain moisture in the soil. The borderline between the aspen forest and the grassland is marked by a band of shrubs which thrive on the increased moisture and help the young aspen crowd out the grasses. Burrowing animals such as ground squirrels, pocket gophers and badgers, can aid the aspen in gaining a foothold in the open areas by turning up loose piles of earth when they tunnel. If conditions are suitable, a windblown aspen seed may land in the exposed soil, germinate, and begin its growth into a new clone.

Prior to the arrival of Canadian and European settlers, fire in the grasslands was a common occurence and served to push back the advancing aspen forest or at least hold it at bay. Aspen trees invading the grassland, surrounded by the dry grasses, could be killed off completely by repeated burning. Fireweed, grasses and other sun-loving plants would pioneer areas where fires had succeeded in eliminating the aspen and, in a few years, a flourishing grassland community would cover the burned site. More slowly, the aspen would once again begin invading the grassland.

Climatic factors also affect the balance of plants in the Parkland. The grassland community can survive long periods of drought while long periods of wet weather are beneficial to the aspen.

Today, the natural fescue grasslands have all but lost the battle for supremacy. Cultivation by man is the most important reason the grassy areas are shrinking — the richest soils lie under the fescue grasslands. But the control of fire has also given the aspen a great advantage so that in areas where man does not interfere with the growth of aspen, it is gradually taking over the grassland.

PARKLAND INHABITANTS

Though aspen and fescue are the two main characters in the Aspen Parkland story, there are many other plants and many animals which play lesser roles. Most of these may be commonly found in the northern forests or on the great plains but rarely in both. Such overlapping is typical in a transition area like the Parkland.

Parkland Plants

The foliage of aspen allows enough sunlight to penetrate to the forest floor to encourage a dense growth of wildflowers and shrubs. Wild Vetch, Baneberry and Red Osier Dogwood are common throughout the grove while Buckbrush, Chokecherry and Prickly Wild Rose may be found along the margins. Balsam Poplar often mixes with Trembling Aspen and can be distinguished by its larger, more oval leaves and pungent balsam aroma. Pockets of White Spruce and mixed forest can be found in some specific areas of the Parkland like river valleys and cooler, moister, north-facing slopes.

The grasses share their habitat with an amazing number of other plants. Lindley's Aster, Three-Flowered Avens, Western Wood Lily and Northern Bedstraw are among the more conspicuous members of the grasslands community. Shrubs such as Buckbrush, Prickly Rose and Gooseberry add to its diversity. Most of these plants share a common tolerance of dry conditions, a short reproductive cycle and a need for direct sunlight. While they are well adapted to surviving drought and pioneering burnt-over areas, they run into trouble when they are encroached upon by the taller aspens. The grassland plants do not thrive in the shade and have difficulty competing with other plants attracted by the increased moisture.

Life on an Aspen

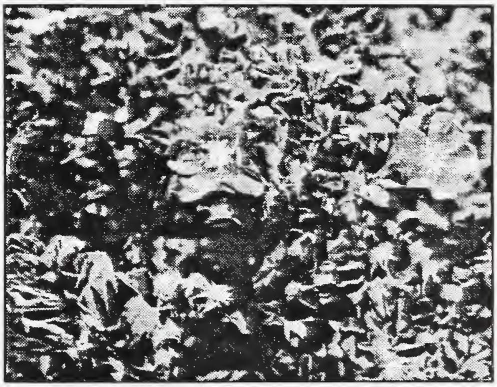
The aspen tree itself plays a very special and direct role in the lives of many Parkland creatures. As the largest plant in the Parkland, it is a prime host, alive and dead, for animals, birds, insects, lichen and fungi.

Insects live in and on the leaves, bark and wood of the aspen. The Aspen Leaf Miner bores between the surfaces of the leaf producing an intriguing pattern. Gall insects lay eggs in the leaf tissue and the presence of their larvae produces bumps or "galls" of abnormal tissue growth on the leaf. These growths provide food and protection for the insect larvae with little harm to the tree. Birds feed on the insects and use the aspen for shelter and nesting, while for Varying Hares and White-tailed Deer, young aspen is an important source of winter browse. Even when dead or dying, the aspen provides for its neighbors. Shelf-like fungus growths indicate that fungus is penetrating the heartwood of an aspen, causing it to rot. As the tree weakens, insects will take up residence in the dead wood and, in turn, provide a meal for an energetic woodpecker. An owl may use the dead tree for a roost and a deermouse may burrow through the punkwood at its base to establish a den. When the tree falls it will be close to completing the important cycle of a natural community. Disease, fungus and insects all assist in decomposing the tree, freeing the nutrients so they can be recycled in the soil of the aspen forest.

Animals - A Choice of Habitats

The diversity of the parkland supports an equally diverse number of forms of animal life. Some are found principally in the aspen forest while others choose to live in the surrounding grassland; a few species range over both areas.

A large variety of plant and insect eating animals depend primarily on the aspen forest. The Porcupine and Varying Hare (also known as the Snowshoe Hare) depend directly on the trees and shrubs for food. Downy and Hairy Woodpeckers, Least Flycatchers and Yellow Warblers feed upon insects found in the aspen grove. The Horned Lark and Meadowlark, whose melodic calls are such a familiar sound in the grasslands, subsist on insects of the fescue community. The Thirteen-



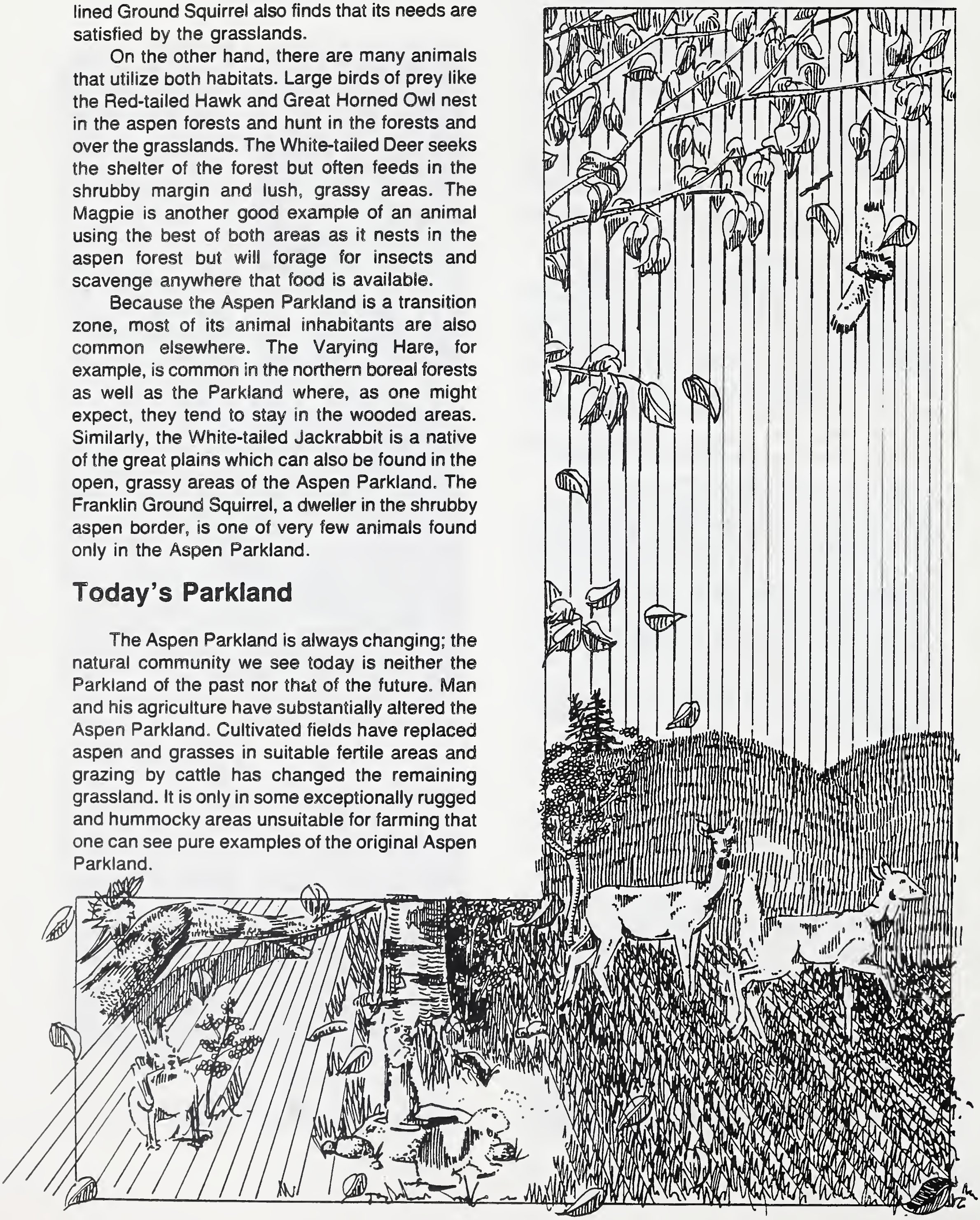
lined Ground Squirrel also finds that its needs are satisfied by the grasslands.

On the other hand, there are many animals that utilize both habitats. Large birds of prey like the Red-tailed Hawk and Great Horned Owl nest in the aspen forests and hunt in the forests and over the grasslands. The White-tailed Deer seeks the shelter of the forest but often feeds in the shrubby margin and lush, grassy areas. The Magpie is another good example of an animal using the best of both areas as it nests in the aspen forest but will forage for insects and scavenge anywhere that food is available.

Because the Aspen Parkland is a transition zone, most of its animal inhabitants are also common elsewhere. The Varying Hare, for example, is common in the northern boreal forests as well as the Parkland where, as one might expect, they tend to stay in the wooded areas. Similarly, the White-tailed Jackrabbit is a native of the great plains which can also be found in the open, grassy areas of the Aspen Parkland. The Franklin Ground Squirrel, a dweller in the shrubby aspen border, is one of very few animals found only in the Aspen Parkland.

Today's Parkland

The Aspen Parkland is always changing; the natural community we see today is neither the Parkland of the past nor that of the future. Man and his agriculture have substantially altered the Aspen Parkland. Cultivated fields have replaced aspen and grasses in suitable fertile areas and grazing by cattle has changed the remaining grassland. It is only in some exceptionally rugged and hummocky areas unsuitable for farming that one can see pure examples of the original Aspen Parkland.



PARKS IN THE PARKLAND

There are twenty Alberta Provincial Parks located in the Aspen Parkland region. Very few are composed to any great extent of the Parkland described in this brochure. Many parks were developed primarily for recreation and are located in river valleys and on lake shores where special conditions of temperature and moisture encourage other forms of plant growth.

Miquelon Lake, Aspen Beach, Ma-Me-O Beach and **Vermilion** are intensive recreation parks where the natural vegetation has been substantially altered. Remnants of the Parkland such as mature aspen stands, can be seen in some areas. Miquelon Lake is also a major waterfowl staging area.

Fish Creek, Big Knife, Pembina River, Red Lodge and **Big Hill Springs** are located in river valleys. Here, spruce and mixed wood forests are often found on north-facing slopes. Big Knife, Fish Creek and Big Hill Springs, however, contain good examples of fescue grasslands.

Dillberry Lake, on the other hand, is typical of a transition area between Parkland and mixed grass prairie. Aside from the lake and the bathing beach area, most of the park is rolling grassland dotted by small aspen and willowbluffs.

Saskatoon Island and **Lac Cardinal** are located in the vanishing Parkland of the Peace River area. Though limited in area, Saskatoon Island is also one of the few nesting sites in Alberta of the rare Trumpeter Swan.

Other lakeside parks such as **Hasse Lake, Rochon Sands, Thunder Lake, Wabamun, Pigeon Lake** and **Jarvis Bay** contain areas of mixed wood forest along with some examples of Parkland plant communities.

Dry Island Buffalo Jump exhibits the most striking contrasts in the Parkland. Aspen clones and fescue grasslands dominate the uplands, but the Red Deer River valley which is 450 feet deep at this point, harbours many different plant communities. Badlands in the valley support southern prairie species and slopes above stream systems have extensive white spruce stands and plants associated with the northern forest.

Suggested Reading

More detailed information about the ecology and natural history of the Aspen Parkland can be found in the following sources:

Bird, R.D. **Ecology of the Aspen Parkland of Western Canada,** Agriculture Canada publication no. 1066, Queen's Printer, 1961.

Braithwaite, M. **The Western Plains** from the series Illustrated Natural History of Canada, McClelland and Stewart, Toronto, 1970.

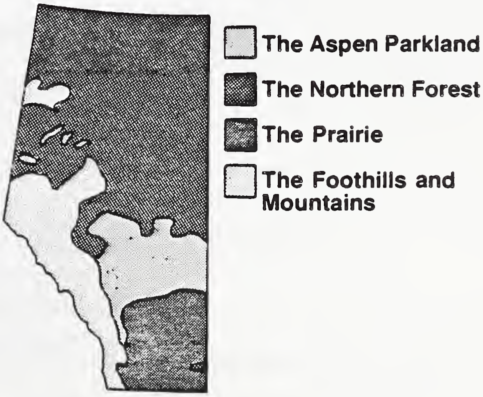
Hardy, W.G. (Editor), **Alberta, A Natural History**, Hurtig Publishing, Edmonton, 1967.

Looman, J. "The Fescue Grasslands of Western Canada", in the journal **Vegetatio**, #19, pp. 128-145, The Hague, Netherlands, 1969.

Steneker, G.A. and Wall, R.E. **Aspen Clones, their significance and recognition**, Canadian Forestry Service, publication no. ODC (181.51), Ottawa, 1970.

Natural Regions of Alberta

The Aspen Parkland is one of four major natural regions in Alberta. This brochure is one of a series designed to introduce you to the main features of the different regions and their provincial parks.



Reprinted courtesy of:

Alberta Recreation, Parks and Wildlife
10363 - 108 Street
Edmonton, Alberta, Canada
T5J 1L8

EXERCISES TO BE SENT IN CORRECTION

Part One: Multiple Choice

_____ 1. If one population fills a niche, that niche could be taken over by another population if

(a) the first population consisted of producers and the second of consumers.
(b) a third population helps the second population.
(c) the second population parasitizes the first population.
(d) the second population out-competes the first population.

_____ 2. Using the competitive exclusion principle we should be able to predict that in a biotic community

(a) there is no competition between species for a niche.
(b) no two species can share exactly the same habitat.
(c) no two species can have identical ways of life.
(d) two species can successfully share the same niche.

_____ 3. The steps that lead to the development of a climax community are known as

(a) the nitrogen cycle. .
(b) ecological succession.
(c) the competitive exclusion principle.
(d) symbiosis.

_____ 4. The first plants to move into a site after a disturbance are known as

(a) pioneer plants.
(b) a sere.
(c) primary succession.
(d) secondary succession.

_____ 5. You would expect primary succession to start taking place

(a) in an abandoned farmer's field.
(b) after a forest fire.
(c) on bare rock.
(d) all the above.

_____ 6. The climax community

(a) is the last stage in a sere.
(b) is self perpetuating.
(c) changes with time.
(d) only (a) and (b)

______ 7. Succession is likely to take place most rapidly

(a) on a newly formed volcanic island.
(b) on rock scoured by a glacier.
(c) after a forest fire.
(d) on a sand dune.

______ 8. Which group represents the most probable order of succession of plants in a rocky barren area?

(a) lichens, mosses, grasses, shrubs
(b) grasses, mosses, shrubs, trees
(c) lichens, grasses, shrubs, trees
(d) lichens, shrubs, trees, grasses

______ 9. The process by which organisms expand their geographic range is called

(a) dispersal.
(b) motility.
(c) primary succession.
(d) secondary succession.

______ 10. The area in the world in which an organism is found is determined by

(a) its mode of dispersal.
(b) barriers.
(c) its ability to compete with other species.
(d) all the above.

______ 11. The disseminule and the mode of dispersal used by most fungi is

(a) spores spread by wind.
(b) seeds spread by wind.
(c) spores spread by water.
(d) seeds spread by man.

______ 12. A species has expanded its geographic range when it

(a) disperses to a new area.
(b) crosses barriers to its dispersal.
(c) is able to survive in a new area.
(d) is able to successfully compete and reproduce in a new area.

______ 13. The house sparow is an example of an organism that has dispersed to North America by

(a) wind.
(b) man.
(c) self dispersal.
(d) water.

______ 14. The species that will enter an ecosystem at any particular stage of a sere are for the most part determined by

(a) the proximity of suitable species.
(b) the amount of available precipitation.
(c) the temperature on a season-to-season basis.
(d) the competitive exclusion principle.

______ 15. Plants are least likely to modify soils by changing

(a) the water holding capacity of the soil.
(b) the pH of the soil.
(c) the nitrogen content of the soil.
(d) the calcium content of the soil.

______ 16. Organisms present in the early stages of a sere may not be present in the climax community because

(a) they have created conditions that do not suit their self-perpetuation.
(b) they are out-competed by other species.
(c) they die out from old age.
(d) only (a) and (b).

______ 17. As succession proceeds there usually is

(a) an increase in the number of species present.
(b) a decrease in the number of species present.
(c) no change in the number of species present.
(d) a decrease in the number of available niches.

______ 18. The end product of succession is a

(a) biome.
(b) primary community.
(c) biotic community.
(d) sere.

_____ 19. Which of the following is *not* a limiting factor in terrestrial biomes?

(a) water
(b) temperature
(c) oxygen
(d) geographic barriers

_____ 20. The major deserts of the world are located in

(a) North America and South America.
(b) North America and Europe.
(c) Europe and Africa.
(d) Africa and Asia.

_____ 21. The taiga is restricted entirely to

(a) North America.
(b) the northern hemisphere.
(c) the southern hemisphere.
(d) northern Asia.

_____ 22. The biome that has climax vegetation consisting of spruce, fir and pine is the

(a) tundra.
(b) taiga.
(c) tropical rainforest.
(d) savanna.

_____ 23. The area that receives the least precipitation is the

(a) savanna.
(b) chapparal.
(c) tropical scrub forest.
(d) desert.

_____ 24. An ecosystem with coniferous forest, deciduous forest, grasses, and alpine meadows would be characteristic of the

(a) mountains.
(b) tundra.
(c) taiga.
(d) prairies.

______ 25. The biome that has as a discontinuous forest canopy is the

(a) moist temperate coniferous forest.
(b) temperate deciduous forest.
(c) savanna.
(d) tropical rain forest.

______ 26. Cariboo, muskox and lichens are characteristic of the

(a) tundra.
(b) taiga.
(c) boreal forest.
(d) savanna.

______ 27. The most likely explanation of why penguins are found in the Antarctic but not in similar ecological conditions in the Arctic is that

(a) the tropics act as an ecological barrier to their dispersal.
(b) there is no food for penguins in the Arctic.
(c) predators have stopped penguins from surviving in the Arctic.
(d) it is too cold in the Arctic.

______ 28. Overgrazing is not likely to be a problem in the grassland if there is a large number of

(a) herbivores.
(b) omnivores.
(c) predators.
(d) decomposers.

______ 29. The biome with the highest rainfall and most uniform climate is the

(a) tropical savanna.
(b) tropical rainforest.
(c) tropical deciduous forest.
(d) moist temperate coniferous forest.

______ 30. The desert

(a) is always hot.
(b) is usually located close to the equator.
(c) receives very little or no rain.
(d) all the above

_____ 31. Temperatures and evaporation rates are highest in the

(a) shortgrass prairie.
(b) mixed-grass prairie.
(c) Cypress Hills.
(d) Aspen Parkland.

_____ 32. Long periods of darkness would be characteristic of

(a) the tundra.
(b) alpine regions.
(c) both alpine regions and tundra.
(d) neither alpine regions nor tundra.

_____ 33. Lichens and mosses are plentiful in the

(a) tundra.
(b) alpine regions.
(c) both (a) and (b).
(d) neither (a) or (b).

_____ 34. Whether a land area, a given distance from the equator supports a deciduous forest or a prairie depends primarily on

(a) temperature.
(b) precipitation.
(c) latitude.
(d) altitude.

In each of the following groups of terms, three represent a biome and one is unrelated. Which is *unrelated* to the others?

_____ 35. (a) tundra
(b) permafrost
(c) ground hog
(d) muskox

_____ 36. (a) Aspen poplar
(b) chokecherry
(c) prickly rose
(d) black spruce

_____ 37. (a) cougar
(b) Columbian ground squirrel
(c) marmot
(d) Franklin's ground squirrel

_____ 38. (a) white spruce
(b) whooping crane
(c) barren ground caribou
(d) pika

______ 39. (a) Sage grouse
(b) rattlesnake
(c) pronghorn antelope
(d) varying hare

______ 40. The largest biome in Canada is the

(a) boreal forest.
(b) grasslands.
(c) Aspen Parkland.
(d) deciduous forest.

Part Two: Short Answer Questions

1. In which biome or ecotone do you live?

____

2. List the dominant producers in your area.

____

____

____

3. List the dominant consumers in your area.

____

____

____

4. Describe the climate in the area where you live.

____

____

____

____

Part Three: Matching

Match each item in the left column with an item in the right column. Write the letter of the correct answer in the space on the left.

______ 1. understory

______ 2. arboreal

______ 3. carrying capacity

______ 4. ecological equivalent

______ 5. limiting factors

______ 6. biome

______ 7. canopy

______ 8. sere

______ 9. rain shadow

______ 10. complex zonation

A. organisms with similar adaptations for filling similar niches.

B. uppermost layer of the forest

C. many habitats in the same area

D. the maximum sustainable yield of a biome

E. vegetation beneath the canopy

F. all the plant communities that lead to the climax

G. occurs on the lee side of mountain ranges

H. tree-living

I. affect the activities of organisms

J. a major regional ecological community

Part Four: Lab Exercise - The Climatogram

Purpose - In this exercise you will learn what climatograms are and how to interpret them. You will also construct and interpret a number of climatograms.

Background Data

Climatograms summarize monthly measurements of only 2 climatic factors; temperature and precipitation. Other factors can also greatly affect climate but the climatogram does give a reasonable indication of the climate for the location where the data was gathered.

Since there is a distinct association between the climate and the biome found in any one region, you can, through daily observation, become familiar with this association. On a world-wide basis it would be quite time consuming to learn about this association between climate and biome for all the biomes of the world. Consequently we must rely on climatograms and descriptions of the biota to learn this association.

Procedure - Part A - How To Prepare A Climatogram

A climatogram is a graph that summarizes two variables, temperature and precipitation. Precipitation is represented by a bar graph while temperature is represented by a line graph. These two forms of graphing are used so that one variable can easily be distinguished from the other.

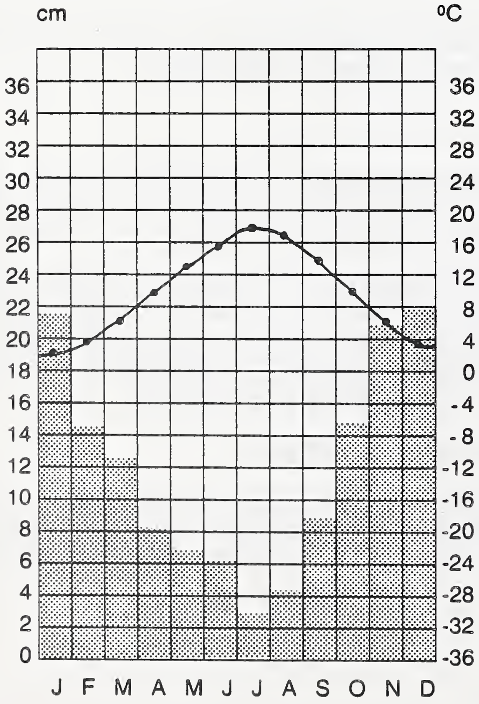
Take a look at the two examples and the data used to prepare them.

Location - Vancouver B.C. - 49° 17'N, 123° 05' W												
Month	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Temperature in °C	2.5	3.9	6.4	9.4	12.8	15.8	17.7	17.5	13.9	10.3	6.4	3.9
Precipitation in cm	21.8	14.7	12.7	8.4	7.1	6.4	3	4.3	9.1	14.7	21.1	22.4

Location - Dawson, Yukon - 64° 04'N, 139° 29' W												
Month	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Temperature in °C	-29.5	-24.5	-15.6	-1.9	8.1	13.6	15.3	12.5	5.6	-3.3	-16.9	-25.6
Precipitation in cm	2.3	1.8	1.3	1.3	2.5	3	3.8	3.8	3.6	3	2.8	2.5

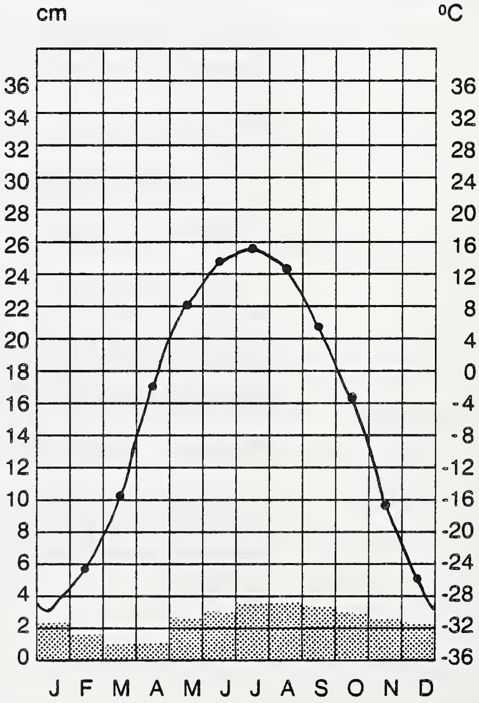
Vancouver, B.C.

Coastal Forest



Dawson, Yukon

Taiga



Use the following procedures to prepare your own climatograms.

1. The monthly temperature averages are plotted on the climatogram from the temperature data (in degrees Celsius) for each location. Use the scale shown on *the right hand side of the graph*. The points representing each monthly average should be at the mid-month position as illustrated in the two preceding graphs. Once you have plotted the points for all 12 months they should be joined by a line.

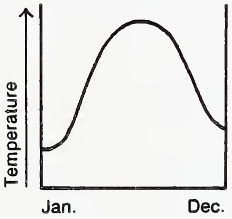
2. The monthly precipitation averages are plotted on the climatogram from the precipitation data (in centimetres) for each location. Use the scale shown on *the left hand side of the graph* to plot the point for each monthly average on the graph. For each point, draw a line the width of the bar. Shade in all bars to make them stand out.

3. Label your climatogram giving name of the location where the data was collected and the biome.

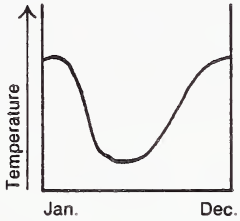
Procedure - Part B - How To Interpret A Climatogram

Use the following data to interpret the climatograms you will prepare.

1. The hemisphere, northern or southern, in which an ecosystem is found can be determined by interpreting the line on the climatogram that represents the temperature. A line showing the highest temperatures in June and July and the lowest temperatures in December and January would indicate a biome in the northern hemisphere. If these temperatures were reversed for the stated times of year the biome would be in the southern hemisphere.

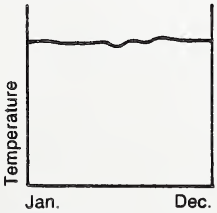


NORTHERN HEMISPHERE

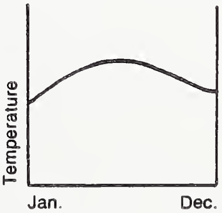


SOUTHERN HEMISPHERE

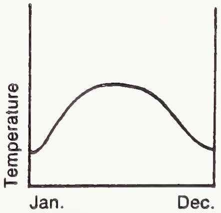
2. The latitude of an ecosystem can also be determined by interpreting the temperature line on a graph. Ecosystems that are equatorial show very little or no seasonal fluctuation in temperature. Generally speaking, as you move farther north or south of the equator, the difference between the summer high temperature and the winter low temperature becomes more extreme. Also, because the amount of solar radiation received as you move away from the equator decreases, the *average annual temperature decreases*.



EQUATORIAL



LOW MID LATITUDES



HIGH MID LATITUDES

3. The biome can sometimes be determined by comparing temperature and precipitation. Plants need a constant supply of water and temperatures above freezing in order to be actively growing. Near the equator, average temperatures are always high enough to maintain plant growth but water can act as a limiting factor. High temperatures and low precipitation will lead to a water deficit due to evaporation of water. When these conditions occur, plants will die or exist in a dormant state. Thus at equatorial latitudes we can find biomes that range from continuously wet tropical rainforests, to seasonally wet deciduous forests, to fairly dry savanna, to very dry deserts.

   At middle and northern latitudes, both precipitation and temperature can act as limiting factors. High summer temperatures and low precipitation can lead to a water deficit, thus affecting the kinds of plants and animals found. As well, *average minimum temperatures* must be above freezing if plant growth is to occur. Below this temperature, plants either die or become dormant. Consequently at mid-latitudes we find middle latitude rainforests (coniferous), middle latitude deciduous forests, taiga chaparral, grasslands and deserts.

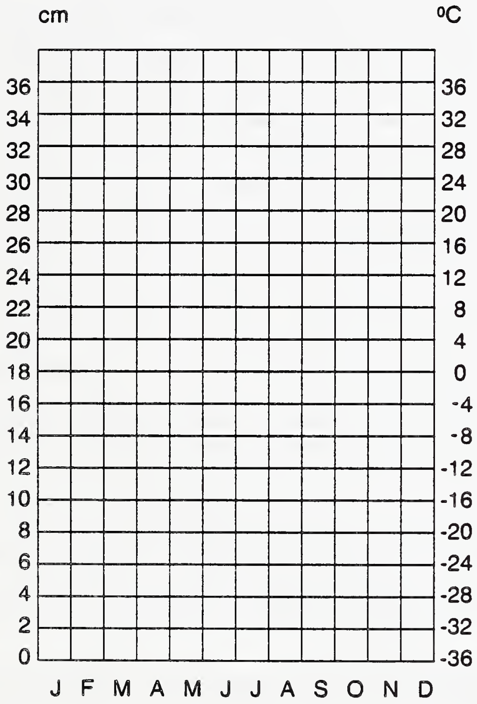
4. Some of the factors that can influence the type of biome present in an area which cannot be determined by reading a climatogram are:

   (a) proximity to large bodies of water (ocean, lakes).
   (b) direction of prevailing wind.
   (c) altitude (mountains - complex zonation).

Assignment

1. Using the following data, construct a climatogram for this mystery location, then answer the questions that follow.

Location -?												
Month	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Temperature in °C	0	0	-0.6	-3.3	-7.2	-10.6	-11.1	-10.6	-7.2	-3.9	-2.2	0.6
Precipitation in cm	3.5	3.75	4.75	4	3	2.5	3.25	3.25	2.75	2.75	3.25	2.5



(a) Which hemisphere is this biome in? Explain your answer.

(b) Is this location near the equator, at mid-latitudes or near the poles? Explain your answer.

(c) Do you think this location is near a large body of water (e.g. ocean) or in a continental location distant from water? Explain your answer.

(d) What is the total annual precipitation? ________ cm.

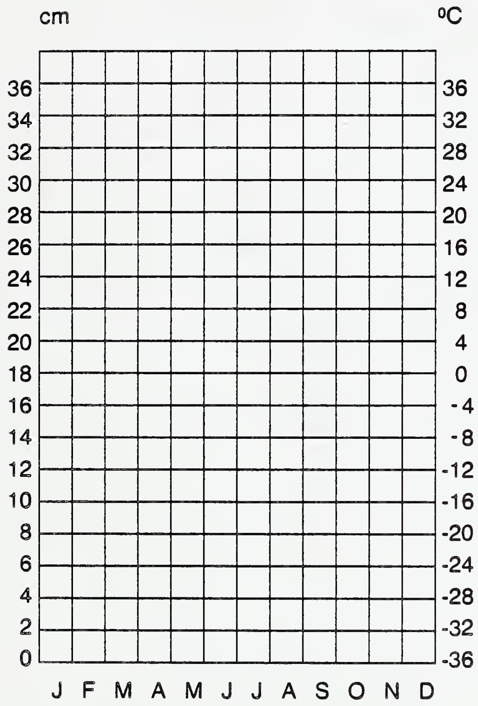
Do you think this would be adequate to support plant life? Explain why.

(e) Based on the data from the climatogram, how long is the possible growing season?

(f) Do you think that producers live in this location? If so, what type of biome do you think it would be?

2. Using the following data, construct a climatogram for this mystery location, then answer the questions that follow.

Location -?												
Month	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Temperature in °C	-9	-8.2	-3.2	3.1	10	13.5	16.9	15.4	10.9	5.6	-2.3	-7.3
Precipitation in cm	1.4	1.7	2.9	3.2	4.9	8.9	6.1	5	4.5	2.3	2	1.6



(a) Which hemisphere is this biome in? Explain your answer.

(b) Is this location near the equator, at mid-latitudes or near the poles? Explain your answer.

(c) Do you think this location is near a large body of water (e.g. ocean) or in a continental location distant from water? Explain your answer.

(d) What is the total annual precipitation? ___________ cm
Do you think this would be adequate to support plant life? Explain why.

(e) Based on the data from the climatogram how long is the possible growing season?

(f) Do you think that producers live in this location? If so, what type of biome do you think it is?

END OF LESSON 3

LESSON RECORD FORM

2230 Biology 20

Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ____________________

Time Spent on Lesson ____________________

(If label is missing or incorrect)

File Number ____________________

Lesson Number ____________

FOR SCHOOL USE ONLY

Assigned Teacher: ________

Lesson Grading: ________

Additional Grading E/R/P Code: ________

Mark: ________

Graded by: ________

Assignment Code: ______

Date Lesson Received: ____________________

Lesson Recorded ______

Student's Questions and Comments

Apply Lesson Label Here

Name ____________________

Address ____________________

____

____

Postal Code ____________________

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____

Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

FRESHWATER AND MARINE ECOSYSTEMS

Freshwater Habitats

READ

Read Chapter 45, pages 653 to 659 of your text, then return to this lesson and continue reading.

The study of freshwater ecosystems is known as **limnology**. In this branch of biology, the two major kinds of habitats studied are the *lentic environment* and the *lotic environment*. The lentic environment consists of still bodies of water such as lakes, ponds, bogs, marshes, and swamps. They vary in size, depth, shape, chemical and biological composition. The lotic environment consists of moving waters such as springs, brooks, creeks and rivers.

Bogs

Bogs are low wetlands where land plants such as sphagnum moss, sedges, willows, dwarf birch, tamarack, black spruce, and labrador tea encroach on lakes and ponds, slowly filling them in through the formation of peat. Peat is the dead, undecayed remains of plants, mostly sphagnum moss and sedges. These plants grow on the margins of the lakes and ponds, forming floatation mats out over the water's surface. The surface mat will eventually close over the lake. Along the way, dead sphagnum, sedges and other vegetation help to fill in the basin.

Because of the acidic nature of these bodies of water, little decomposition of the dead plant matter occurs. The acidity of the water also precludes the growth of most plant and animal species, except for a few acid-tolerant types. Bogs are typical of regions that have undergone glaciation. In Alberta they are found sporadically in the central part of the province, increasing in number as one moves north into the boreal forest.

Swamps and Marshes

Swamps and marshes are other types of low wetlands. Swamps are vegetated predominantly by trees such as cypress and mangrove, whereas marshes are predominated by grasses. Much swamp and marsh occurs in the deltas and floodplains of rivers in the southeastern United States. The Okefenokee Swamp of Georgia, Dismal Swamp of North Carolina and Florida Everglades are amongst the largest. There are no swamps in Alberta, though small marshes occur in the poorly drained sloughs and ponds of the grasslands in the central and southern portions of the province. Cattails and reeds are plants typical of these marshes.

Sloughs and Ponds

Sloughs and ponds are small, shallow bodies of water that may or may not dry up over the course of the summer. Permanent sloughs and ponds are characterized by high rates of productivity, with a large variety of rooted plants, phytoplankton, algae and floating plants such as duckweed. An attendant number and variety of invertebrate species exist to graze upon the producers or other consumers. Vertebrates such as frogs are plentiful. In temperate climates, fish are scarce, due to severe oxygen depletion during the winter freezeover. Organic matter on the bottom begins to decay and oxygen cannot enter the water due to the covering of ice. In summer, these areas form prime nesting and feeding habitat for waterfowl.

Lakes

Lakes have many similarities to sloughs and ponds as well as some unique characteristics. A lake is an inland body of water with its surface exposed to the air. Lakes vary considerably in size and depth. The largest freshwater lake in the world is Lake Superior (80,756 km^2), though most lakes are much smaller, usually less than 250 km^2. The deepest lakes in the world are Baikal (1750 m) in Siberia and Tanganyika (1449 m) in Africa. These lakes are exceptional; as most are relatively shallow, usually less than 30 m.

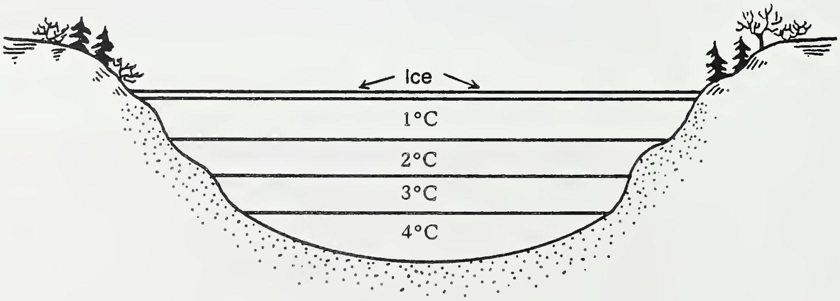
Lakes also vary considerably in age, depending on how and when they were formed. Some lakes are very recent in origin as is Earthquake Lake in Montana, U.S.A. This lake was formed in 1959 when a landslide blocked the Madison River valley. Lake Baikal, formed by a shift in the earth's crust, is thought to be millions of years old.

Lakes are formed in a variety of ways. *Tectonic lakes* may form in the basins created by movements of the earth's crust, such as faulting. *Crater lakes* may develop in the hollow interior of extinct volcanoes. *Glacial lakes* have resulted from glaciers gouging out depressions in the earth which may be filled with the melting of the glacier. Most of the lakes in Alberta are of glacial origin. *Oxbow lakes* form when the meander of a river channel becomes cut off from the main channel. Man is also responsible for the formation of many lakes by the damming of rivers and digging of reservoirs.

Water has some unique characteristics that affect the physical characteristics of lakes and the organisms that live in them. In its liquid form, water achieves its maximum density at 4°C, however it does not freeze until it reaches 0°C. Thus ice is always lighter than water and floats on the surface. This is quite unlike other liquids that achieve maximum density upon freezing and thus freeze from the bottom up. If water froze from the bottom up, the effect on all aquatic organisms would be disastrous. They would eventually be frozen solid over the course of a winter as the ice developed from the bottom to the top of the lake.

Because ice is a good insulator, it protects the water below it from the extremes in temperature that exist—even in the coldest winters. Ice seldom exceeds one metre in thickness. The water directly below the ice is coldest (1°C), but increases in warmth to a maximum of 4°C at the bottom.

Figure 1: Temperatures of a Lake Under Ice



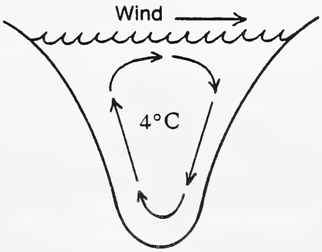
In temperate climates, where winter temperatures get down to a minimum of 4°C, there is a **spring and fall overturn** of all the water in lakes and ponds. In fall, as temperatures begin to cool, the surface temperature of lakes and ponds responds accordingly. When the surface temperature of the water reaches 4°C, it reaches its maximum density and sinks to the bottom of the lake, forcing less dense water to the surface until the whole body of water has reached 4°C.

At this point, the surface water continues to cool below 4°C. Since it is now less dense than the water below, it remains at the surface and continues to cool until it freezes into ice. Over the winter the lake remains in this condition, with the coolest water at the top and the warmest at the bottom.

When spring comes, warmth from the sun eventually melts the ice and warms the surface water up to 4°C, at which time it sinks to the bottom, forcing less dense colder water to the surface in the spring overturn. The action of wind and waves further helps to mix the water at these times of year.

The spring and fall overturns are crucially important to all things living in the lake. Nutrients essential for growth of phytoplankton are brought to the surface and oxygen necessary for respiration by consumers and producers is distributed to the bottom and throughout the lake.

Figure 2: The Spring and Fall Overturn



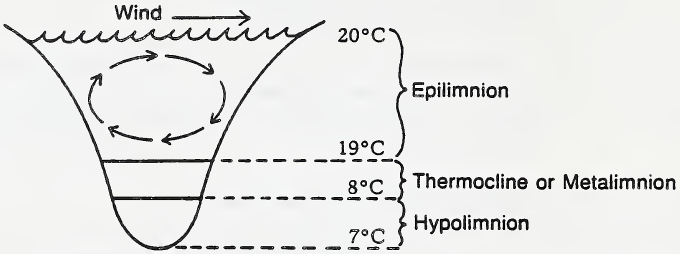
In the summer, or in regions where temperatures remain above 4°C throughout the year, the process of **thermal stratification** will take place in waters deeper than 10 metres. In lakes 10 m or less in depth, the temperature of the water from surface to bottom will be much the same as warmth absorbed at the surface is quickly redistributed to lower levels by the actions of wind, waves and diffusion.

Thermal stratification is the formation of layers of water of different temperatures in a lake. As the sun heats the surface water of a lake, the water increases in temperature and decreases in density. The warmer it gets the less dense it becomes. This results in the formation of a warm upper layer of water, the *epilimnion,* over a cooler lower layer, the *hypolimnion*. Between the two zones is a transition zone, the *metalimnion* or *thermocline*, where temperatures decrease rapidly. Winds push surface waters across a lake to the shore, where they roll downward. When the lighter waters of the epilimnion meet the denser colder water below, they do not mix. The warm water doubles back across the lake just above the cold water. The oxygen from the surface is only carried down as far as the thermocline; colder deeper water receives no oxygen.

In the tropics, where this process takes place year round, you will find no fish or other organisms that require oxygen, because no oxygen gets down to the hypolimnion.

In temperate climates, oxygen is circulated throughout the lake during the spring and fall overturns. During the summer, organisms living in the hypolimnion must rely on oxygen taken in during the spring overturn. If this oxygen is all used in respiration and decay, aerobic organisms such as fish will be forced move up into the epilimnion or die. The oxygen supply of a lake during the winter relies on oxygen taken in during the fall overturn. Since ice covers the lake in winter and there is no wave action to mix oxygen into the water, this can be a very critical time of year for aerobic organisms. If the winter is long enough and snow cover deep enough to inhibit photosynthesis by algae, oxygen levels can become so low as to result in winter kill of aerobic organisms such as fish.

Figure 3: Thermal Stratification of a Lake In Warm Weather



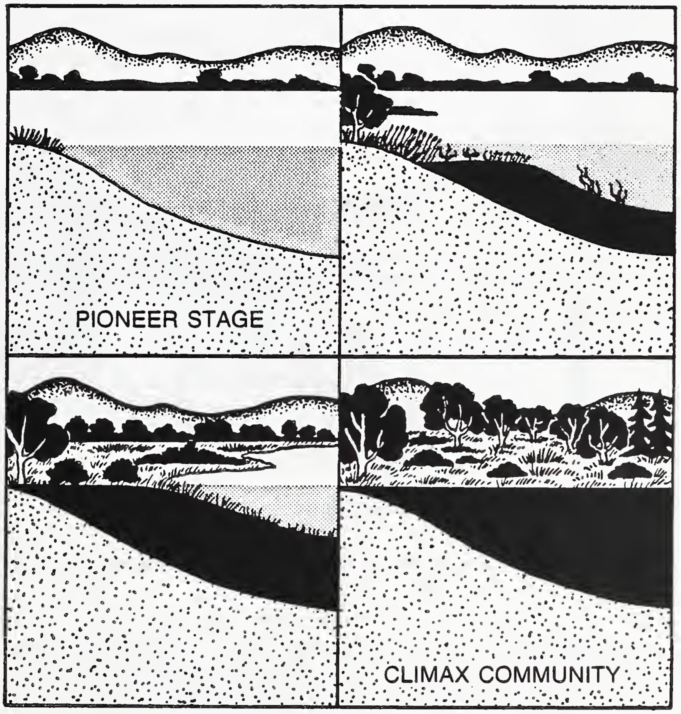
Lakes are also classified on the basis of **productivity**, or their capacity to produce and sustain plant and animal life. Lakes which produce little food relative to their volume are known as **oligotrophic lakes**. These lakes can be described as being cold, deep, usually with clear water, lacking in nutrients, and with a rocky bottom. In Alberta many of the mountain lakes, such as Maligne Lake, are oligotrophic.

Lakes which produce a great deal of plant and animal life relative to their volume are called **eutrophic lakes**. These lakes are fairly shallow, have warm water and a mud bottom. Their shallowness means that they are less likely to exhibit thermal stratification. The water is turbid (lacking clarity) and has more nutrients essential for growth of producers due to decay of previously living things and accumulated sediments. They tend to have a well developed community of rooted plants in their limnetic zone. Pine Lake and Lake Wabamun are typical Alberta examples.

Lakes, on the geologic time scale, are only temporary features. They exhibit a definite lifespan and will eventually fill in to become part of whatever terrestrial biome exists where they are found. In other words they exhibit succession. Oligotrophic lakes eventually become eutrophic lakes. The lake basin becomes shallower by filling in from the bottom up and by the outlet stream, when present, cutting down the barrier that forms the lake basin, thus lowering the capacity of the basin. The basin can be filled in by the deposit of sediment from inflowing streams where present, by erosion of the lake's margins by wave action, and by the accumulation of dead organic matter. Rooted aquatic plants become established on the margins of the lake and as the lake becomes shallower the shore extends further and further into the lake. As more sediments build up around the shore of the lake, it diminishes in size and becomes shallower.

By this point in succession, the lake has been reduced to a pond, marsh or swamp. As it becomes shallower and drier it may eventually dry up during the summer months, much to the detriment of aquatic organisms. Many invertebrate and vertebrate species that are able to survive these dry periods will still be present. The predominant vegetation will be emergent rooted plants such as cattails, sedges and rushes. As succession proceeds, the pioneer terrestrial species move in and the area that was once a lake will eventually become a terrestrial ecosystem similar to the climax community found surrounding the original lake. The time that this takes to happen depends on the size of the lake and the conditions in the surrounding environment.

Figure 4: Succession in a Lake

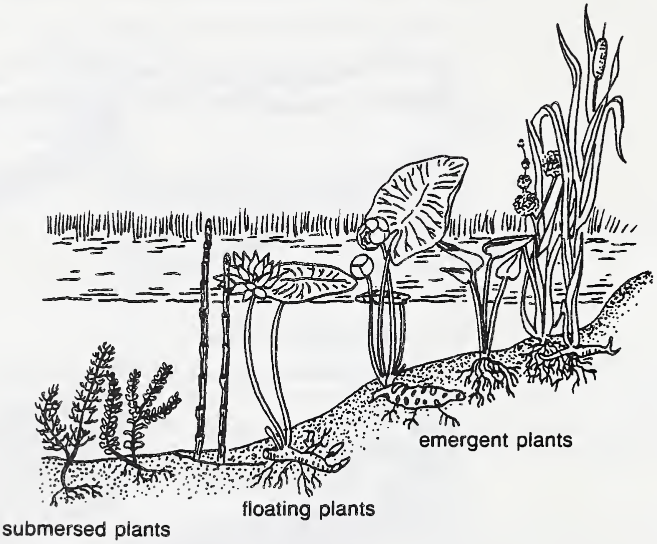


There is a great variety of plant and animal life in the sloughs, ponds and lakes found throughout Alberta. You will now look at some of the more prominent species you might encounter on a field trip to one of these locations.

Living plants are found in the littoral and limnetic zones. Those growing in the littoral zone exhibit a definite pattern of zonation. Closest to shore are the emergent plants, rooted in the soil, their upper portions extending above the water line. Among them are cattails, sedges, reed grass, arrowheads and water horsetail.

The floating plants form the next zone further out from the emergent plants. They may be in water anywhere from a few centimetres to several meters in depth. Most of these plants are rooted, but a few are free-floating. Among them are duckweed and the yellow water lily. The last zone, furthest from shore, is the zone of submerged plants. Large dense mats of vegetation may be formed by a variety of plants that live in this zone. Among these are water milfoil, hornwort, chara and the pond weeds.

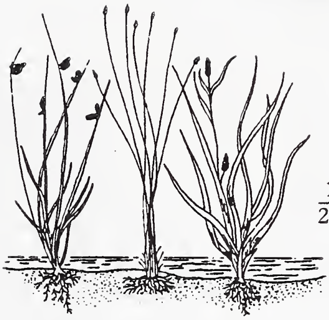
Figure 5 - Zonation of Aquatic Plants



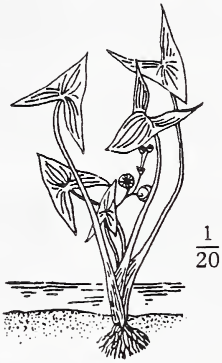
Here are a few of the plant and animal species representative of this ecosystem.

1. Cattails are tall erect plants (one to two m) with long, flat leaves about 2.5 cm wide. They spread mostly from creeping rootstock but bear seed in a brown club-like spike at the end of a long stem. They are a rich supply of food for a variety of insects, birds and mammals such as the muskrat.

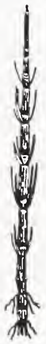
2. The sedges have triangular-shaped, solid stems, unlike grasses that have hollow stems. Flowers and seeds are produced at the ends of the stems.



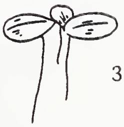
3. Arrowheads are easy to identify, as the leaves are arrow-shaped. Their flower is white. They adjust easily to changing water levels. When stranded on shore the narrow ribbonlike leaves of the submerged stem drop off and develop wider arrow-shaped ones.



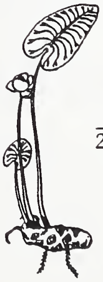
4. Water horsetail grows from creeping underground stems. The erect branches are jointed and bear a whorl of little branchlets at each joint. The tip of the plant may bear a cone-like sporangium.



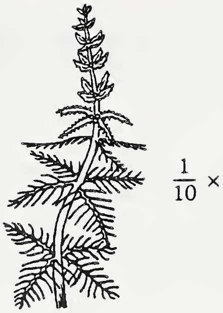
5. The duck weed is a free-floating plant with a very small leaf, 5 to 10 mm in diameter. Two or more roots extend from the base of the leaf. The plants may become so numerous as to completely blanket the surface of small ponds.



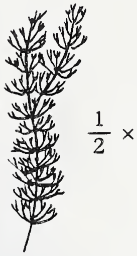
6. Yellow water lily has a fleshy rootstock that lies in the mud. Leaves and flowers float on the surface, attached to the rootstock by a long petiole. Leaves are oval and measure up to 20 cm in length. The plant bears yellow flowers for most of the summer.



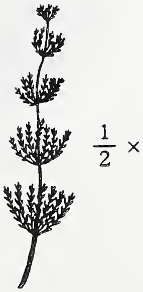
7. Water milfoil is a submersed plant measuring up to a metre in length. The leaves on the lower part of the stem are finely divided. A close relative of this plant, the Eurasian water milfoil, has become a serious problem in many lakes. It grows so rapidly that it can quickly choke out a body of water, making it unfit for other plant and animal life. The plant roots in the bottom, and as the stem reaches toward the surface, it branches out to form a thick mat. The plants become so numerous, they interfere with boating and make swimming dangerous.



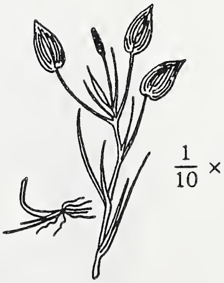
8. Hornwort is another common submersed plant. It has hollow stems and three-forked, filamentous leaves that grow in whorls about the stem.



9. Charas is an algae with bristly stems and branches, which are very hard and brittle from lime deposition. The plant gives the water it grows in a marshy or sulphurous odor.



10. Pondweeds consist of more than 40 species. Leaves of different species range in shape from orbicular to hairlike in this large genus of aquatic plants. It is a favorite food of waterfowl, muskrats, beaver, deer and moose.



11. Among the algae are numerous macroscopic and microscopic forms including spirogyra, cladophora, oscilatoria, nostoc, stonewort and diatoms.

The following are some of the more common animals that can be found in Alberta's freshwater habitats:

1. Mayflies - The nymphs live in water. They can be recognized by the gills on both sides of the abdomen and the long, filamentous tails.

2. Dragonflies - The nymphs are aquatic. They have a stout body and lack external gills. They swim by shooting through the water using jet propulsion. See text page 657.

3. Caddisflies - The nymph is aquatic and can be recognized by the case or house the organism lives in.

4. Damselflies - Nymphs are found in water. They have long slender bodies with three caudal fins. Locomotion is produced by serpentine-like movements. They are similar to the dragonflies.

5. Mosquitoes - The larva and pupa are commonly found in spring and early summer in aquatic environments.

6. Fairy shrimps - These organisms can be spotted early in spring in freshwater environments. They swim on their backs.

7. Copepods - Tiny organisms that can be identified by their jerky swimming motion.

8. Water-beetles and Water-bugs - There are numerous varieties of organisms belonging to these categories. Basically these insects spend their whole lives in water. Some common representatives are the water boatman, backswimmers and giant water beetles.

9. Snails - There are a number of different varieties found in various waters.

10. Tubifex - Small white worms that live in mud cases on the bottom of standing waters.

11. Leeches - Can be found in many freshwater habitats. Their bodies are segmented and usually blackish in color. They are about five cm to eight cm in length.

12. Planaria - Tiny worms found on rocks or on vegetation near the bottom. They are flat and appear as gray jelly blobs.

13. Hydras - Small stationary organisms that look like a bare twig with tentacles on the top end. Common in standing waters.

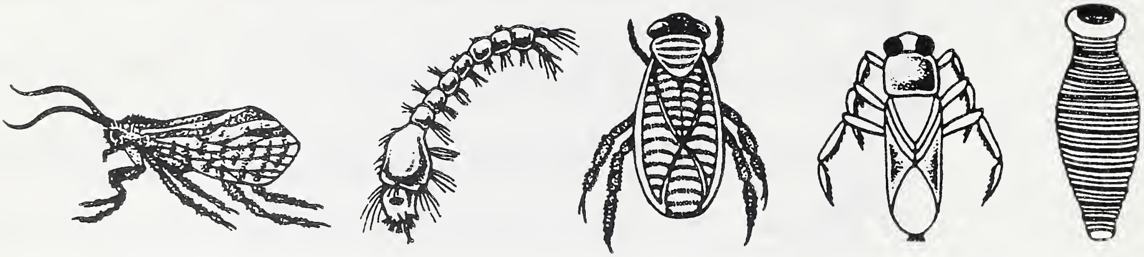
14. Frogs - Plentiful and found in almost any area.

15. Fish - Will be plentiful if there is enough oxygen throughout the year to keep them alive. Cold water species include trout, char and grayling. Warm water species include whitefish, pike and perch.

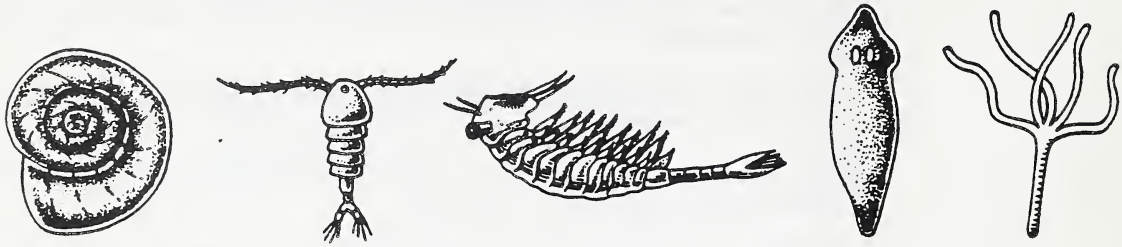
16. Birds - Numerous species of waterfowl can be found, including duck, gulls, and a variety of wading shore birds.

17. Mammals that habit lakes and ponds include muskrat and beaver.

Figure 6 - Selected Fresh Water Animals



CADDISFLY 2x   MOSQUITO LARVA 4x   WATER BOATMAN 2x   BACKSWIMMER 2x   LEECH 1/2x



SNAIL 2x   COPEPOD 10x   FAIRY SHRIMP 5x   PLANARIA 10x   HYDRA 10x

These are but a few of the species found in the lakes and ponds of Alberta. Do take the time to visit and study these interesting and complex ecosystems.

Streams and Rivers

Streams and rivers result from the collection of surplus precipitation as it flows from an area of higher elevation to one of lower elevation, and ultimately to the sea. They have a number of characteristics that make them different from lentic waters. They exhibit current, which is a function of their **elevation gradient**. The elevation gradient is the number of metres a river drops in altitude per kilometre of distance travelled. Mountain streams and rivers have high elevation gradients, which decrease considerably as these bodies of water move through flatter terrain.

The **velocity** or rate of flow of a river, is determined by the gradient. Where gradient is high, the erosive effects of floating water tends to wash away soil. Consequently, stream beds will be rocky. Where gradient is low, the sediments carried in water will be deposited. The lower the gradient, the slower the current, and thus the higher the rate of decomposition of water-borne sediments.

The nature of a river, and the organisms that live in it, will change many times as it floats to the sea. In mountain streams where water is cold, elevation gradients steep, and the bottom rocky, productivity tends to be low. Permanently rooted aquatic plants are almost non-existent under these conditions. A variety of algae are able to cling to rocks by means of sticky secretions. Much of the plant matter that enters the stream comes by means of leaves from trees on the bank. Animal life must be adapted to withstand the current or be swept away. The immature stage of insects such as blackflies, caddisflies, mayflies, and stone flies have adaptations for securing themselves to the bottom. Trout have a streamlined shape and position themselves behind obstructions in the current to maintain their place.

As streams join together to become rivers there tend to be overall changes in the nature of the river. Rocky bottoms are replaced by mud bottoms as sediments filter out in the slower currents. The slower current and increased width of the river lets the sun warm the water more. With more sunlight and a slower current, more varieties of producers are able to grow in the river. Rooted plants and phytoplankton are able to survive, especially in slower moving reaches. Increased plant life also leads to an increase in the number of varieties of consumer present. Cold water species of fish found further upstream are replaced by warm water species such as sauger, walleye, goldeye, and pike.

If you wish to pursue the study of freshwater habitats in Alberta, read the book "*Alberta, A Natural History*," edited by W.G. Hardy. Chapter 10 gives a detailed description of plants and animals that habit the standing and flowing waters in this province.

The Marine Habitat

READ

Read Chapter 46, pages 660 to 669 of your text, then complete the exercises that follow.

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

_____ 1. The lentic habitat includes

(a) lakes.
(b) bogs.
(c) springs.
(d) only (a) and (b).

_____ 2. The limiting factor that is not a part of the lentec habitat is

(a) current.
(b) transparency.
(c) dissolved oxygen.
(d) temperature.

_____ 3. The dissolved oxygen content of water is influenced by

(a) current.
(b) water temperature.
(c) transparency of the water.
(d) only (a) and (b).

_____ 4. The depth of the limnetic zone would be most affected by

(a) dissolved oxygen.
(b) transparency.
(c) temperature.
(d) dissolved minerals.

_____ 5. The lotic community consists of which two zones?

(a) littoral and limnetic
(b) rapids and pools
(c) limnetic and profundal
(d) profundal and littoral

_____ 6. Organisms that rest or swim on the surface of a lake are known as

(a) neuston.
(b) periphyton.
(c) benthos.
(d) plankton.

_____ 7. Phytoplankton differ from zooplankton in that they

(a) live suspended in the water while zooplankton live on the surface.
(b) are much larger than zooplankton.
(c) require light to survive.
(d) are consumers whereas zooplankton are decomposers.

_____ 8. Clams would be considered part of the

(a) neuston.
(b) benthos.
(c) plankton.
(d) nekton.

_____ 9. In the lentic community, the zone that may be missing is the

(a) littoral zone.
(b) limnetic zone.
(c) profundal zone.
(d) both (b) and (c).

_____ 10. In a pond, rooted plants are a part of the

(a) littoral zone.
(b) limnetic zone.
(c) profundal zone.
(d) both (b) and (c).

_____ 11. Organisms living in a mountain stream must be adapted to withstand

(a) the pressure of the current.
(b) low levels of dissolved oxygen.
(c) high levels of dissolved compounds.
(d) all the above.

_____ 12. The biota of the pool zone most closely resembles that of the

(a) rapid zone.
(b) profundal zone.
(c) littoral zone.
(d) limnetic zone.

_____ 13. The great majority of decomposers in a lake would be part of the

(a) neuston.
(b) benthos.
(c) plankton.
(d) nekton.

______ 14. Which of the following does not affect the dissolved oxygen content of water?

(a) temperature
(b) decay
(c) respiration
(d) dissolved minerals

______ 15. The region of highest productivity in a lake is the

(a) littoral zone.
(b) limnetic zone.
(c) profundal zone.
(d) pool zone.

______ 16. Thermal stratification with warm water at the bottom of a lake and cold water at the top occurs during the

(a) winter.
(b) spring.
(c) summer.
(d) fall.

______ 17. The study of freshwater ecosystems is known as

(a) hydrology.
(b) aqualogy.
(c) limnology.
(d) marine biology.

______ 18. The end product of succession in a lake is

(a) an oligotrophic lake.
(b) an eutrophic lake.
(c) a bog.
(d) a terrestrial climax community.

______ 19. An aquatic ecosystem in which the basin slowly becomes shallower because it is filled in with dead plant matter is called a

(a) bog.
(b) marsh.
(c) swamp.
(d) pond.

______ 20. The aquatic ecosystem that has the highest level of productivity is the

(a) bog.
(b) mountain stream.
(c) oligotrophic lake.
(d) slough.

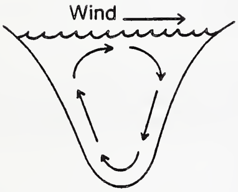
_____ 21. Fish are usually missing from sloughs and ponds because

(a) there isn't enough food in them.
(b) of a shortage of oxygen during the winter.
(c) they freeze to the bottom during the winter.
(d) they are too shallow.

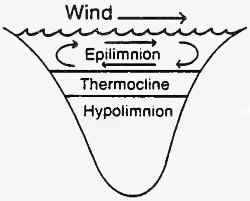
_____ 22. Tectonic lakes form

(a) from the actions of glaciers.
(b) in the basins of extinct volcanoes.
(c) when the meander of a river channel is cut off.
(d) as a result of movements in the earth's crust.

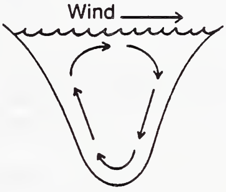
Use the data that follows to answer questions 23 to 27. The four diagrams represent conditions in a lake over one year.



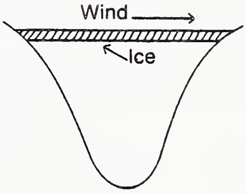
A



B



C



D

_____ 23. This lake is located in a terrestrial ecosystem

(a) in the tropics.
(b) where the temperature never gets above 4°C.
(c) where the temperature never gets below O°C.
(d) where the temperature gets below O°C.

_____ 24. If this lake were located in the tropics, the conditions in the water would most likely be reflected by diagram

(a) A.
(b) B.
(c) C.
(d) D.

_____ 25. The water in diagrams A and C is

(a) O°C.
(b) 4°C.
(c) 8°C.
(d) 12°C.

______ 26. The depth of this lake is probably

(a) 3 metres.
(b) 8 metres.
(c) 10 metres.
(d) 20 metres.

______ 27. The likelihood of death among many aerobic organisms would occur in the lake under the conditions shown in

(a) A.
(b) B.
(c) C.
(d) D.

______ 28. The metalimnion is

(a) the coldest part of the lake.
(b) the warmest part of the lake.
(c) a zone of temperature transition.
(d) at the bottom of the lake.

______ 29. Thermal stratification within a lake with the warmest temperature at the top and the coldest temperature at the bottom would occur in the

(a) spring.
(b) summer.
(c) fall.
(d) winter.

______ 30. Which of the following is not a characteristic of a eutrophic lake?

(a) They usually exhibit thermal stratification.
(b) They have many rooted plants.
(c) They have shallow, warm water.
(d) They have a mud bottom.

______ 31. Succession will take the longest in

(a) an oligotrophic lake.
(b) an eutrophic lake.
(c) a bog.
(d) a pond.

______ 32. Plants in a pond that grow closest to the shore are

(a) in the limnetic zone.
(b) emergent plants.
(c) floating plants.
(d) submersed plants.

_____ 33. A example of a floating plant is the

(a) water milfoil.
(b) yellow water lily.
(c) hornwort.
(d) water horsetail.

_____ 34. The majority of the earth's surface is covered by

(a) terrestrial habitat.
(b) freshwater habitat.
(c) marine habitat.
(d) both (a) and (b).

_____ 35. Recycling of nutrients to the ocean's surface occurs primarily by

(a) ocean currents.
(b) winds.
(c) tides.
(d) upwelling.

_____ 36. The horizontal movement of sea water over great distance is known as

(a) tides.
(b) waves.
(c) ocean currents.
(d) upwelling.

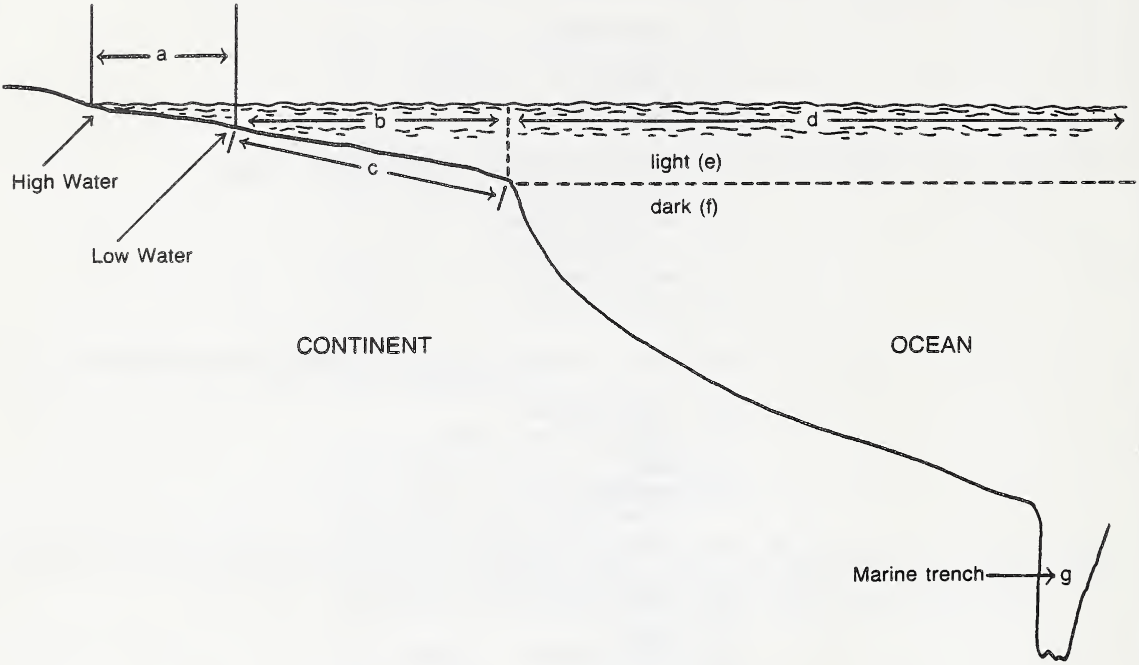
_____ 37. Pelagic organisms include

(a) plankton.
(b) periphyton.
(c) benthos.
(d) all the above.

_____ 38. Corals are members of the

(a) pelagic community.
(b) benthos.
(c) nekton.
(d) neuston.

Use the data that follows to answer questions 39 to 42.



______ 39. The zone most affected by the tides would be

(a) a.
(b) b.
(c) c.
(d) d.

______ 40. The water above the continental shelf is defined by

(a) a.
(b) b.
(c) c.
(d) d.

______ 41. The open ocean is defined in zone

(a) a.
(b) b.
(c) c.
(d) d.

______ 42. Most photosynthesis takes place in zone

(a) b.
(b) e.
(c) f.
(d) g.

______ 43. The major producers of the ocean are the

(a) red algae.
(b) brown algae.
(c) phytoplankton.
(d) sponges.

______ 44. The most productive habitat is the

(a) coral reef.
(b) estuary.
(c) freshwater habitat.
(d) marine habitat.

Part Two: Short Answer

1. Design a freshwater food web with at least six different organisms and four trophic levels.

2. For each of the following biomes, list two producers and two consumers.

   (a) a pond ______________________

   (b) a mountain stream ______________________

   (c) a coral reef ______________________

   (d) an estuary ______________________

3. What possible effects could the addition of sewage to a river have on productivity and dissolved oxygen content? Explain why.

4. Why are living animals found deep in lakes at high latitudes and not in the tropics?

END OF LESSON 4

LESSON RECORD FORM

2230 Biology 20

Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ____________________

Time Spent on Lesson ____________________

(If label is missing
or incorrect)

File Number ____________________

Lesson Number ____________

FOR SCHOOL USE ONLY

Assigned Teacher: ________

Lesson Grading: ______

Additional Grading E/R/P Code: ______

Mark: __________

Graded by: ________

Assignment Code: _____

Date Lesson Received:

____

Lesson Recorded _____

Student's Questions and Comments

Apply Lesson Label Here

Name ____________________

Address ____________________

____

____

Postal Code ____________________

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____

Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

PEOPLE AND THE ENVIRONMENT

Introduction

Humanity does not exist in a vacuum. The human species is biologically tied to this planet as closely as any other living thing. We all depend on the biotic and abiotic features of the earth that provide us with our needs; food, clothing and shelter.

Lesson 5 is undoubtedly the most important lesson so far. In it you will examine the way the ecological principles you have learned so far apply to the human species. You will examine the niches people have filled in different parts of the world in both the past and present. As well, you will examine current ecological problems facing the species, such as population numbers, resource depletion, environmental conservation, and pollution.

The Human Niche - Past and Present

Early humans, such as the Neanderthals are known from skeletal remains found in Europe, Asia Minor, Siberia and North Africa. The remains of Cro-Magnon are known from Europe. The remains of modern humans are known from all continents.

It is believed that modern humans originated in the Eurasian - African landmass and spread out from there. North America and Australia are believed to have been occupied by people at approximately the same time, roughly 30,000 years ago. South America is only thought to have been occupied for the last 10,000 years. People, it is speculated, entered America from Asia via the Bering Strait and Australia by way of the South East Asian Peninsula. Direct evidence of these migrations is lacking but seems the most plausible explanation of these events.

Though there is little written to record activities of people extending back beyond 5 000 years, much has been learned by examining ruins, artifacts, waste heaps, campsites, and the remains of plants and animals found near the remains of the earliest people.

Prior to the advent of herding and agriculture, which are relatively recent events in known history, people lived by hunting and gathering. Roots, berries and other plant matter were gathered as available. The bones of bears, tigers, bison, boars, and other animals, and cave paintings of the hunt indicate that these people were most proficient at hunting. The need to co-operate and plan the hunting of larger animals required that people live in groups and be able to communicate. The remains of fish nets and traps indicate that these activities were also practised. Domestic rubbish heaps, known as *middens*, have been found in some coastal areas. Remnants of these middens indicate that these people relied on fish and shellfish and camped near their food supply. Stone rings and charred bones indicate the use of fire for cooking. Stone tools in the form of axes, scrapers, spear heads and arrow heads were used to gather and prepare food and hides.

Some of these people may have been nomadic, following herds of big game animals. Others may have been quite sedentary if a suitable food source was readily available. Occasionally members of these groups may have been killed through conflict with other groups or died through predation. Parasitism and disease would also have been present. The scattered nature of the human population would not have favored the spread of contagious diseases.

The hunting-gathering lifestyle was practised world wide until the advent of agriculture some 10,000 years ago. The Indian and Innuit of North America practised hunting and gathering until recent times and still do on a limited basis. The Bushmen of the Kalahari and a variety of other groups in the remoter parts of South America, Africa and Southeast Asia still live this way.

As wild food cannot support an ever increasing population, hunter-gatherers must either control their populations or find new and unoccupied territory. This was possible in the past when numbers were small and there was unoccupied space to expand into. The next real increase in the human population had to await the coming of agriculture.

The rise of the agricultural way of life is believed to have occurred somewhere around 10,000 years ago with the domestication of plants and animals. No doubt this was a gradual, somewhat haphazard process. There is little evidence of how domestication of plants and animals took place. It is known, however, by the remains of crops found in prehistoric ruins, that different crops were grown in different areas all over the world.

At different times and in many places, many plants and animals have been domesticated. Wheat, barley, lentils, sheep, pigs and cattle were grown in the Mediterranean. Tools used in this region include hoes, digging sticks and the sickle. Peppers, avocadoes, amaranths, maize, beans and millet were grown in the Americas. Millet, rice, wheat, barley and soybeans were grown in China. It is believed that agriculture expanded from the Mediterranean into Europe.

Thus dawned the age of agriculture and with it one of the most important changes in the history of the human race. People now had the ability to grow food and store it for times of scarcity. This permitted an increase in the number of people that could be supported by an ecosystem and led to large increases in the human population. Towns and cities eventually arose in conjunction with early civilizations. The human species had gone from being merely members of ecosystems to modifiers of ecosystems.

The development of agriculture brought about an increased demand for many new kinds of tools. The food surplus also provided the time necessary for such pursuits. For much of human history stone had been the basic material used in toolmaking. With the discovery of metals a whole new era of development was about to take place. The smelting of metals required heat energy. Since all these resources are not found in the same place, a system of trade and industry slowly evolved where goods for one region were exchanged for those of another. It is known that tin from Britain was traded in the eastern Mediterranean 3,000 years ago. This example illustrates a subtle change in peoples' relationship with the ecosystem in which they lived. Rather than being dependent on the local ecosystem, people were starting to exploit a variety of ecosystems through trade and commerce.

The Industrial Revolution of the 18th century brought about a further increase in peoples' ability to modify the environment and to move rapidly from place to place. The coming of the steam engine and later the internal combustion engine has resulted in the highly mechanized industrial society that exists today. Food and products for shelter now come from all over the earth. Due to modern technology, people, in many respects, are now removed from the environment in which they live. We are sheltered from the environment by our houses, offices, factories and vehicles. We have an extended life span due to protection from disease by the advances in medicine over the last 100 years. The problems the species now faces are not the same as those of the past. We must now deal with the wise use of our remaining natural resources, with ever-increasing population numbers, and with pollution from the improper use of resources. The problems are new and pressing. Their causes are rooted in the adaptive, exploitive nature of human beings. Only if we modify our ways to conserve resources and develop a more balanced relationship with the environment can we be somewhat assured of a bright future.

Population

The earth is a finite entity—they aren't making any more of it. Because of this, the resources that support humans and all other living things for that matter, are also finite. The lesson to be learned from this, regarding population numbers, is simple. A pie divided among four people is ample; the same pie for 40 people would be meagre pickings.

Even if we as a species made it a priority to maximize the number of people on this planet, there is an upper limit which can not be exceeded. We could eliminate predators that compete with us for our food. We could eliminate all first-order consumers except for our domestic animals. We could completely level forests and irrigate deserts in order to increase productivity. We could even eliminate our domestic animals and become vegetarians. But eventually, inevitably, we would reach the maximum sustainable population for the earth.

The previously mentioned methods of supporting an ever-increasing population are not ecologically or ethically sound. Ecosystems with only a few species are unstable. Cultivation of the few crop species favored by humans provides tremendous resources for pest species that also prefer these foods. It is unlikely that we would be able to eliminate all competitors even with massive use of pesticides. Pests such as insects quickly become immune to ever-increasing doses of these poisons. Even if we were able to achieve this goal, would we want to? Could we adapt psychologically to a world with no parks, wildlife or wilderness?

What are the alternatives to an ever-increasing population? At present, space colonies (simple ecosystems) and emigration to planets similar to earth (if they exist) in other solar systems are not technologically feasible. We can increase the death rate through disease, starvation, genocide and war; an unsavory prospect. The only palatable alternative is to achieve a stable human population through **zero population growth**. Zero population growth allows every couple two offspring. This will neither increase nor decrease the population of the planet. Though this sounds simple and is medically quite practical, through various forms of birth control, the achievement of this state is far from reality.

Attitudes that permit population control are not well established throughout society. Religious, cultural and psychological forces tend to support large families or at least work against effective population control. Large population increases have occurred in less developed countries because modern medicine has caused a significant decrease in infant mortality without a corresponding decrease in birth rates. Even though birth rates and population numbers are much smaller in the richer countries of the world (Canada, U.S.A., parts of Europe etc.), they are still increasing. This is especially significant when one considers that the great majority of the earth's resources are consumed by these countries. All countries and all peoples must accept the biological responsibility to stop increasing in number. If we do, within a reasonable time frame, we may have enough food, water, wilderness and other resources to satisfy everyone. If we do not, resource depletion, pollution, disease, and starvation will do it for us.

READ

Read Chapter 48 of your text, pages 682 to 689.

Resources and their Conservation

What are resources? For all living things, resources are the abiotic and/or biotic factors that support life. Producer organisms use air, water, soil and sunlight to produce their own food and to grow. All consumers ultimately depend on the food production capabilities of the producers. Consequently, producers form a necessary resource for consumers by providing both food and shelter.

Over most of the history of the human species, the producers and consumers found in the different ecosystems were the resources of the people who inhabited those ecosystems. Hunter-gatherers used the plants and animals in their surroundings to provide them with food, shelter and clothing. Stone, wood and bone were used to construct tools. With the coming of agriculture, plants, animals, and soils were exploited more intensively. Even at this early stage, people were able to use many resources with great precision. Witness the extensive engineering projects such as the pyramids of Egypt, irrigation systems in Sumaria, and the Mayan temples of Central America. All attest to the ability of humans to use the resources around them and to modify their environment.

Modern technological society has taken a quantum leap in the ability to use and modify the environment. Instead of being ecosystem oriented, we are now globally oriented in the use of a vast array of resources. Fruit and produce from California, salmon from the Pacific, nickel from Ontario, lumber from British Columbia; all are examples of the numerous resources consumed today.

Resources are generally classified as renewable and nonrenewable. **Renewable** resources are those that can be continuously replaced or recycled, or are continuously available. Living things, sunlight, water, air and atomic radiation are considered renewable resources. Other resources, such as metallic ores, coal, petroleum, stone, etc., are considered **nonrenewable** resources because their removal from the earth depletes the usable amount remaining. Even though some of these substances are being formed, the rate of formation is so slow to be considered negligible.

Some resources do not readily fit this simple classification. Soil, for instance, is generally considered a renewable resource. The effects of erosion and nutrient depletion can be corrected quite quickly if either of these processes do not go too far. However, if much topsoil is lost, bedrock exposed, or nutrients and organic matter removed, the process of renewal can be exceedingly slow. Water from underground aquifers also fits this pattern if it is pumped from wells at a rate faster than it can be replaced by the hydrologic cycle.

Soil is one of our most important resources. From it we grow our food, forests (lumber, paper) and grasses for grazing domestic animals. Soil, though considered renewable, is highly susceptible to damage through water and wind erosion under many circumstances. Improper plowing of soils can lead to sheet erosion and gully formation. Sheet erosion slowly peels and splashes away the topsoil from hillsides. These slopes gradually become less fertile and eventually have to be abandoned. Where farming is practised in semi-arid lands, plowed soils can be blown away in years of drought. Overgrazing by cattle can change the species composition of semi-arid grasslands, making them less productive and subject to wind erosion. If the process takes place over a long enough period, desertification may actually take place. The growth of towns and cities has resulted in the paving over of much top quality farm land. Water erosion of soil can also occur when forests are clear cut and logging roads are put in. This may lead to the siltation of streams, which degrades habitat for fish such as trout.

Energy is a very important resource, especially in more technologically advanced countries. Energy is available in sort of a mixed bag of renewable and nonrenewable sources. Renewable forms of energy include solar, wind, geothermal, nuclear and hydroelectric. Nonrenewable forms of energy include coal, oil and natural gas.

Solar energy is most often used to supplement home heating and domestic water heating. It is a readily available, nonpolluting form of energy. However, it is not always available at night or in cloud and is fairly expensive to capture due to the cost of solar panels.

Wind is not strong or steady enough in all locations to make it a reliable source of energy. Currently it is used in some locations to generate electricity by wind generators. Historically it has been used to process food in windmills and for moving sailing ships.

Geothermal power is derived from heating which takes place in the earth's crust. In parts of New Zealand, Iceland, Italy and California, it is used for purposes such as space heating and generating electricity. Its limited distribution will make it only a regionally feasible source of energy.

Nuclear power is used to generate electricity. Though it is renewable, it has a number of serious drawbacks. Firstly, reactors produce a tremendous amount of heat and must be kept cool. Water is used as the coolant, consequently the lake or river that supplies the coolant water is subject to thermal pollution. Secondly, the spent fuel from the reactor remains radioactive, thus dangerous to all life, for a very long time. This presents storage problems which have not been successfully worked out.

Hydroelectric power, while nonpolluting, is capital intensive because dams and hydro transmission towers are very expensive to construct. Furthermore, dams stop fish migration. This has had a serious effect on salmon populations which can no longer reach their spawning grounds on ocean-flowing rivers that have hydroelectric projects. A dam can be of value in controlling flooding, supplying irrigation water, and providing a recreational lake on the reservoir formed behind the dam. These benefits are somewhat offset by drawbacks such as the lowering of flow rates on the rivers below the dam, which can have serious effects on the biota that habit the river below the dam. Also, fluctuations in the shoreline due to water release, that occur in the lake formed behind the dam, prevent the establishment of vegetation along the shoreline and make the lake less attractive as a recreational resource. As well, much of the valley above the dam is flooded.

Coal was the first fossil to undergo extensive exploitation by human beings. With the invention of the steam engine in the 18th century, its use became widespread. Coal has been used for steam powered trains, ships and cars. It was used extensively for home heating, and still is to a certain extent. Coal is still used in the processing of steel and generating electricity. Coal was one of the first substances to cause air pollution. Air pollution due to coal was not uncommon in the industrialized parts of Europe and North America even in the 1800s.

Sulphur dioxide, released when coal and oil is burned, is responsible for pollution known as **acid rain**. Acid rain has killed the biota of hundreds of lakes in Eastern Canada and Europe and done a great deal of damage to forests in these regions as well. It is a major concern among conservationists today. There are still major reserves of coal that have not been mined, so at current rates of use this resource should not run out for several hundred years.

The two remaining fossil fuels, oil and natural gas, were not widely used until the invention of the internal combustion engine and the car in particular. Now they are used extensively in the manufacture of plastics and synthetic fibres, for heating, for transportation (cars, trucks, ships, jets), and for agriculture. **Widespread use of gasoline in the private automobile is responsible for most of the air pollution that exists today.** Based on projected rates of use and rates of discovery, scientists predict the world will run out of oil and natural gas somewhere between 2020 and 2070. We have already seen dramatic increases in the cost of these substances since the 1970s and can expect ever spiralling costs. Conservation and development of alternate sources of energy and lifestyles must be high priorities as the day approaches when these resources are depleted.

Wildlife, both plant and animal, can be considered a renewable resource because it has the ability to reproduce. The problem of conserving wildlife appears fairly simple. Provide an adequate habitat for each species to reproduce, match rates of harvest with rates of reproduction, and everything should work out all right. Unfortunately, that simple solution is not so simple to put into practice. In the past, humans have hunted many species to extinction or near extinction. Witness the fate of the extinct passenger pigeon, dodo, and heath hen as well as the endangered whooping crane, sea otter, tiger, blue whale plus numerous other species of mammals, birds and reptiles. Bison in the hundreds of thousands, once covered the plains of North America. They became almost extinct at the turn of the century due to the senseless slaughter by advancing settlers. They are on the return in the National Parks in Canada though none live wild.

Many species are still in danger of becoming extinct due to the activities of people. Numerous species of big game animals are still poached in the game reserves of Africa. Animals are poached for food and for profit; elephant tusks and rhinoceros horns, tiger skins, etc, are sold on the black market. A number of species of whale have been hunted to near extinction by whalers from Japan and Russia. Even rare cacti in the deserts of south western U.S.A. are threatened by plant collectors.

Probably the biggest threat to wildlife at the hands of people is the destruction of their natural habitats. As the grasslands are plowed, the rainforest felled, the rivers dammed, the marshes drained, and roads, towns and cities are built everywhere, the specialized habitats of plants and animals with restricted distributions are squeezed till they disappear. Many organisms have disappeared. Others will disappear along with their vanishing habitats.

Besides the resources just discussed, people make use of many other resources, such as water, forests, and a myriad of metals and chemicals. Each has its attendant problem as far as extraction and use are concerned. One of the largest problems related to resource use is pollution.

Pollution - What is it?

Pollution! Increasing concern about threats to the environment has been centred around a number of adverse conditions which in one way or another combine to deteriorate the quality of life on the planet Earth. These conditions have been categorized under the all-inclusive term, pollution.

Pollution is like the weather, in that everyone talks about it, except that people rarely think or do anything about it until it affects them adversely — until it is almost too late. Unlike the weather, which one individual cannot control or change, pollution and its results can be altered by the individual. The individual with knowledge and concern can begin to become part of a solution to a problem that threatens the environment and, in turn, human existence.

The remainder of this lesson will attempt to define pollution, state the various types of pollution and establish the facts about pollution. You will then be encouraged to seriously consider present and future consequences of continued pollution and the abuse of our natural resources such as water and air. As an individual you should consider what you can do to control pollution.

Pollution takes on many forms and yet is not always identifiable. The meaning of pollution varies from individual to individual and even more so when large groups are concerned.

Pollution is defined in the *Pollution Reader*, "The Phenomenon of Pollution" by H.P. and Blanche Van Ginkle as "The addition of foreign matter to the natural environment to a degree which is insupportable by nature."

The same term as defined by the Meteorological Branch of the Department of Transport Canada relates it directly to people. Pollution is "any material in the air that causes humans discomfort, interferes with their health or damages their property."

To others pollution is simply contamination.

There are many ways of describing pollution. The important point that all definitions have in common is that they describe pollution as being harmful to the environment and to people.

If we consider pollution to be the addition of contaminants to the environment in such quantity that go beyond natural tolerances and that the natural processes of restoration are inhibited, perhaps causes and effects should be considered. For example, one person using laundry detergent is not likely to contribute an intolerable amount of contaminants to the environment. Would the effect be the same if 100 000 persons in a restricted area such as a city each used an amount equal to that of the individual?

One car in an area produces a tolerable amount of air and noise pollution. Would the effect be the same if 100 000 cars were used more or less at the same time in a large city? One cigarette smoked in a room produces a small amount of contamination. Is the effect the same when many cigarettes are smoked simultaneously and continually?

Public opinion has a great influence on standards set for pollution control. If there is a high level of public support, then standards of control will likely be high and adhered to. Low levels of public support, would generate the opposite effect. The recognition of cause and effect of pollution is important if control is to be achieved.

There are no simple solutions to pollution control problems. Pollution of the environment has increased rapidly due to higher population densities throughout the world and the nature of the waste material, much of which is not biodegradable (eg. plastics, tin foil). Effective control must be brought about. Attitudes must change; techniques and guidelines must be developed and used. One thing is certain however, pollution is everyone's concern and everyone's responsibility. Pollution control must be practised by every individual citizen as well as by industries and governments.

Environmental pollution has gained recognition as a serious problem. Ever since human beings have inhabited the earth, they have brought about changes, some harmless to the environment and some very harmful. Advanced technology is speeding up the contamination of the environment with gases, acids, metals, radioactive materials and poisons which are damaging to health. Contaminations and alterations of the environment take place. High levels of noise, trash and garbage are created. The environment, like people, has limitations to the abuse it can tolerate.

If programs are to be extended to control pollution of the environment, one of the first things that must be determined is why and how people contribute to the pollution of their surroundings. Peoples' attitudes and the relationship between humans and nature must be considered.

In this lesson, four major types of pollution will be considered — air, water, land and noise.

Air Pollution

Air is a mixture of a number of gases. Nitrogen and oxygen make up about 99 per cent of the atmosphere, the layer of gaseous matter surrounding the earth. Carbon dioxide and a few other gases make up the rest. Air also includes water vapor, but the amount varies constantly. At any given time, air may also contain contaminants produced by natural processes such as volcanic action, forest fires, dust storms and decaying vegetation.

The atmosphere forms a continuous layer around the earth and extends out from the surface for distances of 400 to 1440 km. About 95 per cent of the total air mass is concentrated in a relatively thin layer near the surface of the earth. (The atmosphere becomes less dense until it finally merges into space.) This thin layer, known as the troposphere, varies in thickness from about 8 km at the poles to approximately 17 km at the equator. This layer is important because weather is created within it. More important, it contains the mixture of gases upon which life on the planet Earth depend. Animal and plant life depend on oxygen. Plants also depend on carbon dioxide. Temperature control and precipitation are also influenced by the troposphere.

The air around you carries many particles and gases from natural sources such as bacteria, spores, pollen, meteoric and volcanic dust, soil dust, sodium chloride from ocean spray, and ozone and nitrogen dioxide created by lightning. These are products of natural processes and under normal conditions nature can disperse these materials. Because air is fluid, these agents are able to move around in the atmosphere where their concentrations are reduced.

Rain, snow and dew help to wash the air by removing dust and smoke particles, and by dissolving some of the gases such as nitrogen dioxide. Some of the other gases are absorbed by plants, soil and water. Under normal natural conditions, the removal of these natural contaminants is in balance with their production, therefore the air remains relatively clean. Pollution occurs when the balance is upset by contaminants being added to the air faster than they can be removed.

The major polluters of the air can be placed into two categories — the individual citizen and industry.

Pollution enters the atmosphere in three basic ways:

1. Friction (substances rubbing together) causing the release of contaminating particles.
2. Vaporization from industrial processes involving high heat.
3. Combustion of organic compounds such as fossil fuels.

A. The Major Air Pollutants

Carbon Monoxide (CO): A colorless, odorless, tasteless gas produced by the incomplete combustion of fuel, particularly in motor vehicles. Pure gasoline burned yields carbon dioxide and water. Gasoline is not pure but a concoction of hydrocarbons and additives to assure "total performance" in your car's engine.

Gasoline consists of three kinds of hydrocarbons:

Paraffin	burns well at low speeds
Olefin	
Aromatics	burns well at high speeds
PLUS	
Tetraethyl lead	to prevent paraffin explosion before ignition and eliminate engine knock
Ethylene dichloride	to prevent lead buildup on plugs and valves
Antioxidants	
Metal deactivators	
Anti-rust compounds	
Anti-icing compounds	
Detergents	
Lubricants	

Thus, gasoline burned, yields NO_2, CO_2, CO and hydrocarbons. These emissions are a result of unburned fuel, poor ignition system conditions, too rich or too lean fuel-air mixtures, low operating temperatures, or valve problems. To provide more efficient use of fuel and decrease emissions to the atmosphere, manufacturers have redesigned engines and installed electronic ignition, catalytic converters, heated intake air, and carbon canisters. The use of unleaded gas, propane and diesel also reduce CO emission.

CO replaces oxygen in the red blood cells, reducing the amount of oxygen that can reach the body cells and maintain life. Lack of oxygen affects the brain, and the first symptoms are impaired perception and thinking. At elevated levels this can aggravate the condition of people with chronic heart and respiratory disease. Further inhalation of CO can lead to rapid death as CO locks onto the hemoglobin molecules in the blood preventing the transport of O_2 into the body and CO_2 out.

Ozone (O_3): A pungent, colorless gas that forms in the air as a result of the sun's photochemical action on hydrocarbons and oxides of nitrogen, such as those released by automobiles. Ozone also occurs naturally at levels not much lower than those known to be toxic, particularly in areas of high elevation. High levels of ozone by itself or in combination with other substances can cause eye irritation, breathing difficulty, vegetation damage and decreased visibility.

Nitrogen Oxides (NO): Nitrogen oxide is a relatively non-toxic gas formed mainly in combustion processes where nitrogen and oxygen combine under extremely high temperatures. However, nitrogen oxide converts readily in the atmosphere to nitrogen dioxide (NO_2), a much more toxic, irritating gas that can in the long term combine with water to form acids. It also contributes to the formation of ozone and photochemical smog. Nitrogen oxides can affect health, suppress growth of vegetation, corrode metals and reduce visibility. It is a contributor to acid rain.

Particulates: Particulates are tiny particles of solid or liquid matter that tend to remain suspended in the air, such as mist, dust, aerosols, smoke and soot. When these fine particles enter the respiratory system, people with respiratory ailments may experience difficulty in breathing. Particulates can also decrease visibility.

Sulphur Dioxide (SO_2): Sulphur dioxide is a colorless, pungent gas which smells like burnt matches. It is formed when sulphur and oxygen combine, usually as a result of burning fuels containing sulphur or as a by-product resulting from the removal of sulphur from natural gas and crude oil. The gas combines with water to form acids that can corrode metals, irritate the eyes and lungs and damage vegetation. It is a contributor to acid rain.

B. Effects of Industrial and Automotive Pollution

1. A direct result of the gasoline pollutants plus sulphur dioxide from industry is the creation of photochemical smog. An increase in smog is accompanied by a decrease in sunlight and visibility.

2. A buildup of CO_2 results in the "greenhouse effect." Light energy radiating from the sun is absorbed by the earth and re-radiated as heat energy. Due to the presence of water vapor in the air, and to a lesser degree, the carbon-dioxide and ozone, the atmosphere can and does absorb heat energy. The greenhouse effect is a phenomenon where the air acts like a glass in a greenhouse allowing the light to pass through but holding back the re-radiated heat.

3. Directly affecting each individual is the increased buildup of carbon monoxide which has an affinity for hemoglobin and results in the body supplying less oxygen for respiration. The body can tolerate 10 parts per million (ppm) CO but the maximum allowed before decreased sensitivity to surroundings, lack of energy, and endurance occur is 30 ppm. The average smoker is already at this level and a heavy smoker is subjected to a danger level when he breathes air containing 30 ppm. However, the risk of danger to one's health increases due to automobile emissions. Cars stopped at a light can increase the CO content of the atmosphere to 370 ppm.

4. Studies indicate that an increase in pollution results in an increase in respiratory diseases. There are four particular diseases that fall into this category.

(a)	Bronchitis:	Caused by permanent damage of bronchial tubes decreasing ciliary action while increasing mucus production. Condition results in chronic cough, mucus buildup and shortness of breath.
(b)	Bronchial Asthma:	Reaction of membranes to foreign material causing membranes to swell. Results in difficult expulsion of air, wheezing and shortness of breath.
(c)	Emphysema:	Due to constriction of bronchioles, inhalation and exhalation of air sacs often cause sacs in lungs to swell and burst. Air sacs then unite resulting in a decrease of capillaries for oxygen intake. A decrease in oxygen capacity affects the body by causing chronic shortness of breath.
(d)	Lung Cancer:	A direct result of carcinogens such as benzpyrene, associated with coal smoke, and cigarette tars inhaled by the smoker, which inhibit cilia action.

C. Acid Rain

Normally, rainfall is somewhat acidic because of carbon dioxide naturally present in the atmosphere. Industrial pollutants and particles in the atmosphere can make rainfall more acidic than normal, resulting in what is termed acid rain.

Acid rain causes chemical changes in soils and water bodies. Over a long term, these changes can reduce soil fertility and kill fish and plant life in lakes. In northern Ontario, at least 200 lakes have been robbed of life by acid rain. Increased acidity may also cause secondary chemical reactions that release toxic compounds in soil and water.

Rainfall monitoring and sampling confirm that precipitation is up to 10 times more acidic than normal over almost all Eastern Canada. Over most of Western Canada, on the other hand, rainfall readings are normal or even less acidic than is usual for clean rain.

Three elements are necessary for acid rain to become a serious problem:

(a) pollutant sources (usually large industrial or urban areas)

(b) meteorological conditions that transport pollutants and allow acid rain to form

(c) an environment sensitive to acid rain.

For all three elements there are significant differences between Western and Eastern Canada.

1. **Pollutant source** - Acid rain is the direct result of pollutant emissions into the atmosphere. The two main culprits are sulphur dioxide and nitrogen oxides. In the atmosphere they are chemically transformed into secondary products that acidify rainfall. Because wind may transport these products hundreds or even thousands of kilometers, acid rain can fall far from the original pollution source.

   Sulphur dioxide is generally a by-product of industrial processes and burning of fossil fuels. Ore smelting and natural gas processing in Canada and coal-fired power generators in the United States are the main contributors. About half of the nitrogen oxides emitted are by-products of exhausts from cars, trucks, and other forms of transportation. The rest come from coal-fired power generation and other industrial processes.

   There are fewer sources in the western provinces and states, and they are not concentrated, but spread over a large area. Because pollutant emissions are significantly lower, there is less potential for precipitation to become acidic.

2. **Meteorological Conditions** - Prevailing weather patterns determine where pollutants will be deposited once they leave the source. In North America, the prevailing atmospheric movement is from west to east. Thus, in general, emissions released in the west are transported eastward. Emissions produced in eastern North America also move eastward; they do not affect Western Canada.

   When a high-pressure system sits over eastern North America, moist air circulates from south to north and back again. Because the air flows over areas with high pollutant emissions, the concentration of pollutants keeps increasing. When rain falls, it will be acidic. A high-pressure system also occurs in western North America but does not create an air pollution problem because pollutant emissions are so much lower. As well, because there is less rainfall over the prairies, fewer pollutants are washed out of the atmosphere by rain.

   While atmospheric movement from west to east benefits Western Canadians by sweeping pollutants away, it also imposes a responsibility to ensure clean air for all neighbors to the east, in the same way that users of prairie rivers must preserve water quality for downstream users.

3. **Environmental Sensitivity** - In some cases nature is able to cope with acid rain. Alkaline lakes and soils—those in areas of limestone—are able to neutralize acidity in precipitation. Many areas in eastern British Columbia and on the prairies have alkaline lakes and soils. Therefore, even if the acidity of precipitation increases, environmental effects should be minimal.

However, not all areas are naturally protected. Lakes and soils resting on granite bedrock, such as in the Canadian Shield areas of northeastern Alberta, northern Saskatchewan and Manitoba, and in some areas of western British Columbia, cannot neutralize acid precipitation. Lakes in these areas are as vulnerable to acid rain as those in northern Ontario. They must be protected from exposure to acid rain; if not, environmental damage could be swift and serious.

D. What is Being Done?

The pace of industrialization in Western Canada and the northwestern United States is accelerating. Emissions of sulphur dioxide in Alberta, for example, are projected to double over the next 25 years.

Environment Canada and the environment departments of Alberta and Saskatchewan began a joint study in 1980 to assess the long-term environmental effects of industrial development in northern Alberta and Saskatchewan.

Air quality and the acidity of precipitation and lakes will be monitored to detect whether changes are taking place. Laboratory studies will determine how acid rain affects western soils. Computer programs will be used to simulate the atmospheric movement of pollutants at both the current and projected emission levels so that concentration and deposition of pollutants may be predicted.

(The above was an excerpt from Environmental Canada: "Acid Rain. The forecast for Western Canada.")

The following is a brief summary of air pollutants.

Pollutant	Sources	Typical Effects
CARBON DIOXIDE (CO_2)	Low concentration normal in atmosphere, elevated levels due to increased burning of fossil fuels	Possible increase in global temperature, perhaps resulting in major weather alterations
CARBON MONOXIDE (CO)	Natural decay (93% of total) Internal combustion engines, 25-120 ppm in city traffic Cigarette smoking, 300 ppm in smoke	O_2 deprivation by inactivation of hemoglobin
NITROGEN OXIDES nitric oxide (NO) nitrogen dioxide (NO_2)	Natural processes (1 billion tonnes/yr. world) Internal combustion engines, industrial boilers (50 billion tonnes/yr. world)	Respiratory tract disease, emphysema Damage to vegetation Metal corrosion
SULPHUR OXIDES (SO_x) sulphur dioxide (SO_2) sulphure trioxide (SO_3) sulphuric acid (H_2SO_4)	Sulphur-containing fuel (coal, oil). SO_2 converts to SO_3 and sulphuric acid in air.	Respiratory tract irritation Damage to vegetation Destruction of metals, paints, plastics
PHOTOCHEMICAL OXIDANTS ozone(O_3) peroxyacetyl nitrate (PAN) $CH_3CO_3NO_2$	Reaction of NO_2 with vaporized hydrocarbons in sunlight	Reacts with hydrocarbons to form toxic compounds producing eye and respiratory tract irritation, damage to vegetation, deterioration of fabrics, rubber
HYDROCARBONS methane (CH_3) benzene (C_6H_6) (many others)	Partially burned petroleum fuels Car and truck refuelling Industrial processes Forest fires and agricultural burning Natural decay	Contribute to formation of photochemical smog, some are carcinogenic
PARTICULATES (aggregates of solids or liquids up to 500 μm diameter)		
asbestos	Building and ship insulation Automobile brake lining wear Certain types of rock used in road surfacing	Asbestosis (emphysema-like effects) Lung cancer, diseases of the lining of the lung cavity
coal dust	Coal mining	Black lung disease of miners
metals lead	Fuel anti-knock compounds (use decreasing), coal burning	Disorders of nervous system
mercury	Industrial processes, agricultural chemicals	Disorders of nervous system
allergens	Primarily pollen, especially ragweed Fungi from moldy hay Chemicals used in polyurethane paint	Hay fever, asthma Farmer's lung Asthma
MISCELLANEOUS fluorine compounds	Phosphate fertilizer manufacture Aerosol propellants (chlorofluorocarbons such as $CFCl_3$)	Damage to vegetation Possible reduction of ozone layer
industrial and agricultural chemicals ammonia	Fertilizer	Corrosive and deadly in high concentrations
chlorine	Industrial processes	Corrosive and deadly in high concentrations, skin disorders in chronic exposure

Figure 1: Sources and Effects of Air Pollutants

Water Pollution

Water is absolutely essential to life for without it no living organism could survive. Water appears to be readily available and perhaps supplies of fresh, potable water are taken for granted. Consider the facts about water quantities by examining the following chart.

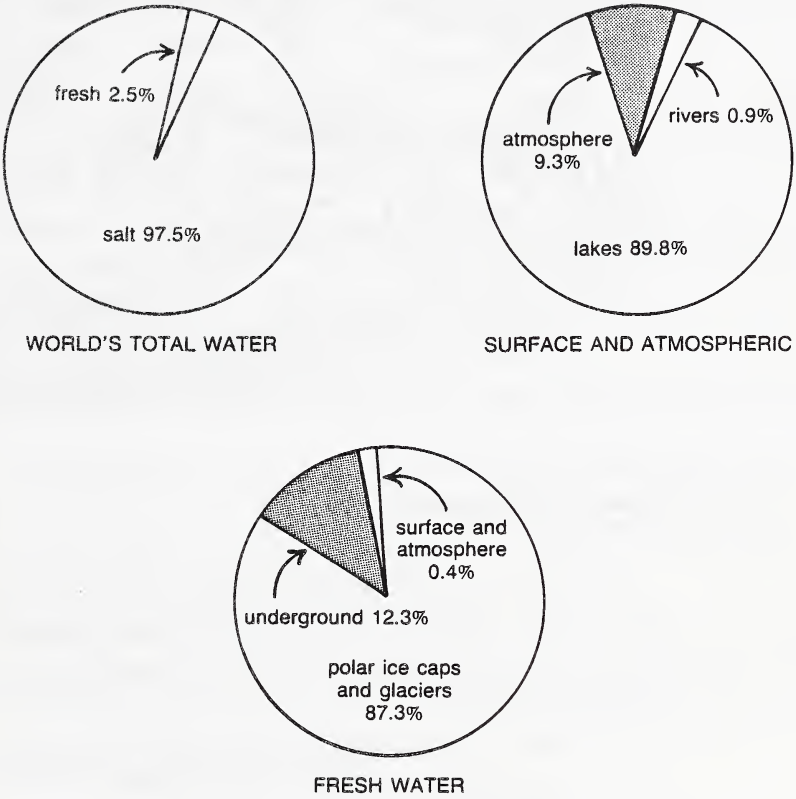


Figure 2: Available Water

One-hundredth of one per cent of the world's water sustains the earth's total population. Most of the water used is available in the rivers and streams of the world.

Atmospheric water falls as rain or snow. It moves over the land through rivers and lakes, percolates under the surface of the earth and eventually returns to the ocean. At every point along the way and from the ocean as well, water is constantly evaporating and returning to the atmosphere. This cycle is called the **hydrologic cycle**, and acts as a distilling and circulating agent. The distillation serves to purify water of its contaminants. Refer to the diagram on the following page.

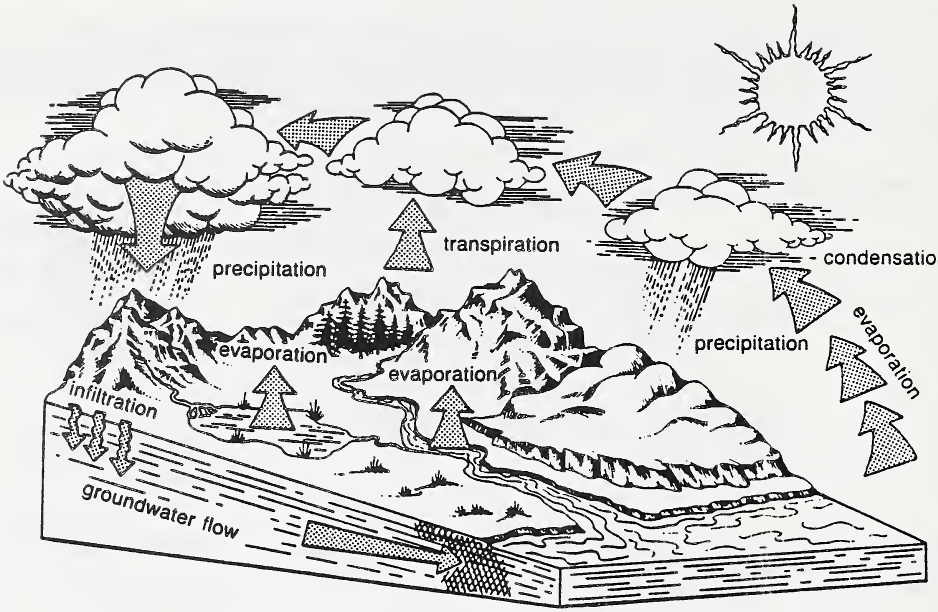


Figure 3: The Hydrologic Cycle

It is evident that what appears to be a great abundance of water for human use is really not great at all. Therefore, if pollution continues, the supply will decrease even further.

Water has been described as nature's most versatile compound since it has a number of unique characteristics.

1. Water can absorb heat without a great rise in temperature. As a result, oceans and large lakes effectively reduce extremes of climate by acting as temperature moderators.

2. Water evaporates very slowly compared to most other liquids, but the evaporation that does take place has a significant cooling effect. This allows for maximum cooling in industrial processes with a minimum of water.

3. Water will adhere to certain material, but only if oxygen is present in the chemical structure of the other material.

   Adhesion, the attraction to other substances, and cohesion, water's attraction to itself, combine to produce capillary action, the ability of water to rise. This characteristic allows plants to draw water from the soil, and allows the soil to hold water against the pull of gravity. Without capillary action, plant growth would be impossible.

4. Probably the most important characteristic of water is its ability to dissolve other substances. Most known chemical elements can be found in solution in the earth's waters. Because of its solvent characteristic, water is essential to life. It is the agent which transfers within living animals and plants the compounds without which life is not possible.

Strangely enough, the properties that make water such a versatile compound also aid in making it so susceptible to pollution. There are a large number of possible water pollutants. In fact, any element not occurring naturally in water can be considered a pollutant. Following are some of the more troublesome pollutants introduced into rivers and lakes by human activity:

Nutrients: These are common elements such as oxygen, carbon, nitrogen and phosphorus required to support life. Excessive nutrients often cause troublesome algae growth leading to eutrophication. Excessive nutrient build-up causes an increase in plant life and a deficiency of oxygen in the water. Death of organisms may result.

Phenols: These are organic chemicals which may, in high concentrations, be toxic to fish. They may also cause unpleasant tastes and odors when water is chlorinated.

Oil and Grease: These may be liquid fats of animal or vegetable origin, or oily or waxy mineral oils, often originating with the petroleum industry.

Heavy Metals: These are metals such as zinc, nickel, copper and mercury which may be highly toxic to life in the river.

Thermal Pollution: Many industries use water but do not consume it, and so return it to the river after use. The returned water is often polluted though, either by the addition of undesirable material, or by heating during use as in cooling processes. Pollution such as this is a major problem where many industries are concentrated along one stretch of a river, as is the case in both Edmonton and Calgary.

Pesticides and herbicides: Farmers everywhere depend on rainfall to make their crops grow but careless farming methods can cause pollution. A fast runoff of rainfall results in erosion of precious topsoil and can cause streams to become filled with sediment. As well, it may wash agricultural chemicals such as fertilizers and pesticides into streams causing damage to stream life and negating their usefulness on the land. Some of these chemicals are toxic; their use is carefully controlled.

Bacteria: Undesirable bacteria may enter a river through insufficiently treated sewage. Rivers are, and can be used effectively to dispose of wastes, but abuse can easily lead to a severe pollution problem. A watercourse is able to absorb certain amounts of wastes. Sewage going into a river is diluted, and bacteria act on it to break it down. With the high demand placed on rivers as carriers of waste, it is necessary that this process of treatment be maintained and monitored constantly.

Suspended Solids: These are undissolved, often minute particles of matter suspended in water, giving it a turbid appearance. Included in this category are soil and dust which may be washed into a river.

In considering stream pollution, the amount of water in a river, and consequently the amount of dilution that takes place, is of prime importance. Partially for this reason, pollution always shows up more during the winter when the lack of rainfall and runoff causes low flows in rivers.

Although human beings are the major source, many of these pollutants do occur in nature. Erosion carries soils and heavy metals into watercourses. High concentrations of mercury have been noted where no human activity has taken place. Phenols in water may be the result of decaying vegetable or animal matter, and muskeg areas may add an odor to the water.

These natural pollutants will always exist. Lakes and rivers can handle this load, as well as some additional pollutants introduced by people. The task that faces us is one of controlling the types and amounts of material going into the watercourse, in order to maintain the water in a useful condition for ourselves and for generations to come.

The following is a summary of pollutants of freshwater.

Pollutant	Typical Effects	Sources
DISEASE AGENTS		
bacteria		
cholera		
typhoid fever		
bacterial dysentery		
viruses	Various acute or chronic diseases	Raw human sewage contaminating food and drinking water. Reduced substantially in developed countries due to chlorination of water supplies and sewage treatment.
infectious hepatitis	Dysentery (severe diarrhea)	
poliovirus		
protozoa		
Entameoba histolytica	Dysentery	
Naegleria	Amebic meningoencephalitis	Thermally polluted water
PETROLEUM	Directly toxic to all forms of life, physical smothering effects	Waste from transportation, heating, industrial accidents. Major source is unwanted motor and industrial oils (3 million tonnes/yr. worldwide).
OXYGEN-USING WASTES (biodegradable)	Reduction of available oxygen causes loss of desirable organisms and replacement by anaerobes, with resultant production of odorous toxic substances	Sewage Paper mill wastes Meat-processing wastes Feed-lot runoff
SYNTHETIC ORGANIC COMPOUNDS		
detergents		
biodegradable	Phosphate build-up	Household, commercial washing
non-biodegradable	Long acting surface effects–foaming rivers.	Household, commercial washing
pesticides	See page 17.	Agricultural, industrial wastes
herbicides	See page 17.	Agricultural, industrial wastes
industrial wastes	Thousands of substances involved in an industrialized economy produce a wide gamut of effects.	Industrial accidents, waste disposal
INORGANIC SUBSTANCES		
arsenic	Skin and liver cancer, a cumulative lethal substance	Arsenic-based pesticides and herbicides account for most of 13,000 tonnes/yr. worldwide production
cadmium	Circulatory and kidney disease	Mine wastes, battery manufacturing, electroplating
chlorine	Generally deadly to aquatic life; possible carcinogenic effects as it reacts with organic substances in water	Industrial, water and sewage purification
mercury	Central nervous system and kidney disorders	Industrial wastes, agriculture (fungicides), coal burning
sulphuric acid	Directly lethal to aquatic life	Coal mine wastes
PLANT NUTRIENTS		
nitrates, nitrites	If present in drinking water are dangerous to infants by inactivating hemoglobin. May form carcinogenic N-nitrosoamines	Fertilizer runoff, manure, natural weathering, nitrogen fixation by microorganisms
phosphates	Phosphate build-up	Agriculture
potassium compounds	Build-up of potassium compounds	Agriculture

Figure 4: Freshwater Pollutants

Soil Pollution

Soil pollution is a serious problem and has reached a high level of public awareness as human technology continues to advance. A soil pollutant may be considered as any substance, chemical or otherwise, which interferes with the soil's ability to yield high quality crops, which creates a hazard to the health of living organisms, and which creates litter. Soil pollution, air pollution and water pollution are often related in that the pollutant may be transferred from one to another.

For the purposes of this lesson, three categories of materials which constitute soil pollutants will be considered. They are **solid wastes, chemical wastes,** and **radioactive and hazardous wastes**.

A. Solid Waste

The control of solid waste disposal is an important part in the program of prevention of soil pollution. Tin cans, empty packages, food scraps, beverage bottles and wrappers are but a very few examples of refuse created by members of a community each day. Commercial wastes from retail and wholesale businesses, old car bodies, old household appliances and furniture, industrial wastes, feed lot manure, leaves, grass cuttings and garden debris, as well as many other forms of materials add to the long list of waste that must be disposed.

Refuse disposal problems are not new to the modern world. At almost every step in the development of civilization, the amount of solid waste refuse has increased. Members of primitive societies handled the problem easily. They simply moved to a new location and left the rubbish behind. Modern fixed communities of today's world are not so fortunate. As these communities increase in size, less and less land is available for refuse disposal.

Many methods of solid waste disposal have been attempted; some have been discarded while others are still being practiced. New methods are evolving.

The **open dump** or **nuisance ground** is still used primarily in rural areas. These are unsightly collections of all garbage and refuse of a community. Frequently, attempts are made to burn some of this material. Smoke, foul odors and bits of paper carried by the wind create very unsightly and unpleasant conditions in the surrounding area. These open dumps are an ineffective means of disposing garbage safely since there are few or no regulations or controls on the materials being disposed. Industrial wastes could be deposited here.

Incinerators at one time were used but these were only partially successful as high temperature, clean-burning incinerators are expensive. From an economic point of view, open low-budget pits supersede the use of efficient incinerators that must be maintained and staffed.

In Alberta, the greatest quantities of solid refuse are disposed of in **landfills**. A landfill is an area where a layer of refuse is deposited in a prepared trench or excavation. It is then compacted by some means to layer depth of approximately 0.6 m. After the compacting, the layer of refuse is covered by a layer of soil. The next layers of refuse and soil are added alternately until the excavation is filled. The final covering layer of soil must be at least 0.6 m deep.

A landfill built on a clay base, planned and operated properly, is relatively safe. This method of disposal limits immediate danger to health, is relatively free of odors, and the cost is comparatively low. A landfill is not the best way to dispose of wastes but it is the most economical in the short term.

In some cases, it has been proven that a landfill is not always "safe." Once the landfill is covered or capped, aerobic organisms no longer break down the wastes; instead anaerobic organisms function. Methane gas is produced as a product of this action. This gas must be released in a safe manner. If released properly, methane gas can be collected and used as an energy fuel. Therefore, the landfill once covered is still an "active organism" breaking down the wastes deposited in the earth by people.

Once the landfill is completed it remains in the area forever. It can be unsightly at times if it does not fit into the geographic layout of the environment. Also, if industrial wastes are inadvertently deposited, they could cause "landfill leaks" and lead to health problems. However, in Alberta, precautions are taken and the landfills in urban areas are carefully monitored to ensure wastes are disposed of properly.

The advantage of a properly developed landfill is that normally unusable land may be made useful for purposes such as parks. The safety of an old landfill site depends on its location, construction, and the wastes deposited in it.

The ultimate form of disposal is the high efficient, clean-burning but expensive **incinerator**. Wastes would be broken down and others would be recycled. Resource recovery would operate "hand in hand" with incinerators. **Recycling** usable forms of refuse is becoming more popular. Industries are making new products from what was once waste material. Glass is being recycled in the form of glasphalt, concrete, building bricks and reflective paint. Car bodies are being recycled and the steel is used in the production of reinforcing steel for concrete structures. Paper is another product being recycled and used in the manufacture of several secondary products such as building materials.

Unfortunately, when disposing of solid wastes, short-term costs seem to be favored over long-term benefits. It is for this reason landfills are the dominant form of solid waste disposal.

B. Chemical Waste

From the time of World War II to the present, a very great number and variety of chemical compounds have been developed. Eventually, these compounds contact the soil by some means or other for purposes of rodent, insect, weed and fungus control. These are generally referred to as rodenticides, insecticides, herbicides and fungicides. All fall under the general term **pesticides**. We may add fertilizers to this list, although application of these chemicals is for a different purpose.

Fertilizers are chemicals designed to supply growing plants with elements necessary for complete growth when such elements are lacking in the soil's natural makeup. When used with proper consideration for the amounts and types to be applied after soils have been analysed, fertilizers do play a positive role in food production. However, overuse of fertilizers often results in surplus nitrates being washed into bodies of water where they create problems. Water supplies, heavily contaminated with nitrates, produce harmful effects on organisms. Fertilizers are widely used in homes, gardens and agricultural areas of the world.

Rodenticides, insecticides, herbicides and fungicides are beneficial if used with extreme care and caution. However, widespread overuse of these chemicals has created and will continue to create serious problems. Such agents are used quite freely in the home, on lawns, in gardens, in city parks as well as in large agricultural fields, and forests in rural areas. Eventually, many of these pesticides end up in bodies of water where they affect aquatic organisms.

These poisons have the ability to be passed along a food chain from producer to consumer. Consequently, it is the animals at the upper end of the food chain that have a high concentration of chemicals in their bodies. These chemicals bring about effects far removed from their original intent.

Mineral pollution of the soil is a serious problem, for often plants absorb minerals that are harmful to organisms. This type of soil pollution is increasing in spite of the fact that it is not as obvious as water or air pollution. The following are examples of mineral sources which lead to soil pollution:

Source	**Mineral**
Smelter slag Phosphate fertilizers	Lead, cadmium
Pesticides	Arsenic, mercury, lead
Coal and wood ash Automobile exhaust - lead eventually settles to ground	Lead

Various industrial operations, particularly large smelters, are capable of adding large amounts of these industrial pollutants.

Because of the widespread use of chemicals resistant to breakdown, continued application causes a build-up of harmful agents, to the point where their abundance exceeds nature's ability to remove them. Therefore, they become pollutants and the soil becomes polluted.

The following chart illustrates some effects of widely used pesticides.

Chemical	**Effects**	**Sources**
PESTICIDES Chlorinated Hydrocarbon Insecticides DDT	Kidney and liver damage, endocrine disorders, impaired neural function	Since 1945, used worldwide as insecticide. Use has declined but still highly persistent in environment. Other chlorinated insecticides include aldrin, dieldrin, chlordane, heptachlor, endrin, methoxychlor
Kepone (chlordecone)	Serious neurological effects, possible liver cancer	Insecticide manufacture (accidental contamination)
Organophosphate Insecticides Malathion	Acute effects on nervous system	General purpose insecticide, the least toxic of the organophosphates. Not persistent in environment
Herbicides 2,4,5-T	Chloracne (persistent skin disorder), liver and kidney failure, developmental abnormalities	Used as weed and vegetation killers

Figure 5: Effects of Pesticide Use

C. Radioactive and Hazardous Wastes

At present, radioactive wastes are not in great abundance in Alberta. Those present are removed in two ways:

(a) Radioactive wastes are held in lead containers or steel insulated containers until decay is such that radiation is no longer dangerous. Materials are then deposited in the conventional manner, in a landfill or are incinerated.

(b) Radioactive wastes with low level radioactivity but persistent in nature are shipped in properly sealed insulated containers to Chalk River, Ontario. In Ontario, wastes are reprocessed and stored in containers underground indefinitely.

Hazardous wastes are generally defined as "any material that would do harm if released to the environment." This term can include a wide variety of wastes but generally hazardous wastes do not break down and many are known to be carcinogens. Examples of two such wastes are PCB and PVC. Refer to the following diagram that illustrates their use and effects.

Chemical	Typical Effects	Sources
INDUSTRIAL CHEMICALS PVC (polyvinyl chloride)	Liver cancer	About 10 million tonnes/yr. worldwide production, a basic component in plastics industry
PCB (polychlorinated biphenyl)	Long-term effects similar to DDT	Used for heat transfer and insulation in power transformers, lubricants. Highly persistent in environment, accumulated by body fat
PBB (polybrominated biphenyl)	Persistent skin disorders, joint disease, neurological disorders	From plants manufacturing fire retardants

Figure 6: Hazardous Wastes and Their Effects.

In Alberta, hazardous wastes are deposited by three methods.

(a) Small volumes of chemicals used by laboratories and schools are neutralized at the source.

(b) The University of Alberta has a disposal facility to handle its own wastes and can handle some outside sources.

(c) Larger volumes of wastes are handled by a company in Alberta that ships hazardous wastes to Oregon where they are placed in a landfill. Proper procedures are taken to neutralize the wastes and monitor the storage.

At present, Alberta has located a site in Swan Hills to build a reprocessing plant for hazardous wastes. These wastes will be reprocessed into less hazardous forms and be deposited in a well monitored landfill.

Noise Pollution

The following material is an excerpt taken from "A Pollution Primer" prepared by Environment Canada.

Noise, like other pollutants, makes our environment less hospitable. Once we become accustomed to the presence of loud noise we tend to take less notice of it and as a result can subject ourselves to dangerous levels without really being aware of it. Real harm can be done. Excessive noise contributes to human stress, often producing such effects as hypertension, fatigue and impaired hearing.

The intensity of sound is measured in decibels on a basic scale ranging from 0 to 150. Zero represents the faintest sound that the unaided human ear can detect. A purring cat registers approximately 25 decibels while a barking dog registers about 65 decibels. Continuous noise above 80 decibels can cause hearing loss and a sound level of 90 decibels can be tolerated only for short periods. Temporary deafness can be caused by even short exposure to levels of 100 to 105 decibels. A sound of 130 decibels is perceived not only as sound but also as a painful sensation in the ear. Typical sounds of high intensity are those created by a subway train screeching around a curved track (95 decibels), motorcycles (110 decibels), a jet plane taking off (150 decibels).

Refer to the following diagram illustrating the decibel values of environmental sounds.

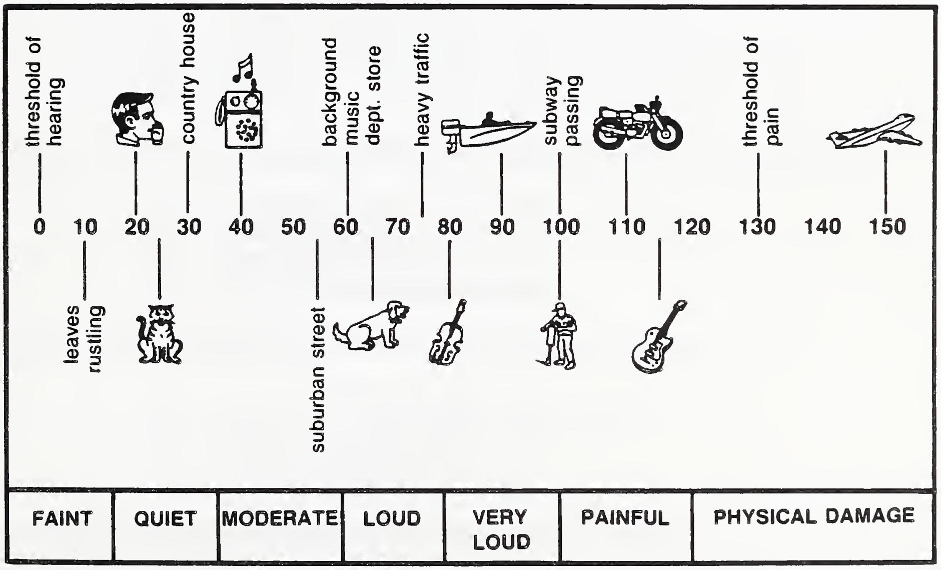


Figure 7: Decibel Values of Environment Sounds

Most cases of actual hearing loss are due to industrial noise and occur as the result of continuous exposure to high levels over a number of years. Home and recreational noises, however, can be a major irritant. Power mowers, radios, stereos, outboard motors, chain saws, and powered appliances make it almost impossible to escape unwanted noise anywhere near a settled area.

Aside from hearing loss, noise can increase body tensions, affecting blood pressure and the functions of the heart and nervous system. It can also cause skin to pale, muscles to tense, blood vessels to constrict, and trigger such ailments as stomach ulcers and allergies.

The present day urban environment is steadily becoming more noisy, some say at an average of one decibel per year. Attempts are being made, however, to remedy the situation. An example is the placement of berms or sound barriers between major roadways and residential areas.

READ

Read section 43-4 on page 635 and 636 and section 43-9 on page 640 of your text, then complete the exercises that follow.

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

______ 1. An example of exponential growth is

(a) 2, 4, 6, 8, 10
(b) 1, 2, 3, 4, 5
(c) 3, 6, 12, 24, 48
(d) 4, 8, 12, 16

______ 2. If a population is increasing exponentially it could be increasing

(a) at a rate of 2% a year.
(b) by 10 individuals a year.
(c) by 100 individuals a year.
(d) all the above.

______ 3. For world population to stabilize, the growth rate would have to be

(a) a negative number.
(b) 0 per cent.
(c) 1 per cent.
(d) 1.7 per cent.

______ 4. According to population scientists, one of the factors responsible for limiting populations is the

(a) availability of food.
(b) daily variation of environmental temperatures.
(c) time required for ecological succession.
(d) lifespan of the members of the population.

______ 5. Desertification occurs because of

(a) the cutting down of forests.
(b) the overgrazing of grasslands.
(c) the plowing of semi-arid grasslands.
(d) growing the wrong crops in arid lands.

______ 6. Which of the following is a possible consequence of deforestation?

(a) soil erosion
(b) habitat destruction
(c) flooding
(d) all the above

______ 7. The remains of Cro-Magnon humans were found in

(a) Europe.
(b) Asia Minor.
(c) Siberia.
(d) all the above

______ 8. The earliest people existed by

(a) herding animals.
(b) hunting and gathering.
(c) fishing.
(d) agriculture.

______ 9. The human species is believed to have entered North America via

(a) Greenland.
(b) the Bering Strait.
(c) the Polynesian Islands.
(d) the South East Asian Peninsula.

______ 10. The development of towns and cities first occurred

(a) while man was still a hunter-gatherer.
(b) shortly after the development of agriculture.
(c) among nomadic herdsmen.
(d) after the Industrial Revolution.

______ 11. Maize is believed to have been domesticated in

(a) China.
(b) Europe.
(c) the Mediterranean.
(d) America.

______ 12. The relationship between humans and domesticated organisms can best be described as a special form of

(a) predation.
(b) mutualism.
(c) parasitism.
(d) competition.

______ 13. The practice of modern medicine has had the most direct effect on

(a) human evolution.
(b) the extension of life span.
(c) the length of community food chains.
(d) reduction in population pressures.

______ 14. Which is **not** an objective of family planning?

(a) zero population growth
(b) decreased world hunger
(c) increased death rate
(d) decreased birth rate

______ 15. How many offspring is a family allowed to have under the system of zero population growth?

(a) 0
(b) 1
(c) 2
(d) 3

______ 16. The final impact of humans on their environment will be due to

(a) their numbers.
(b) the consumption of food.
(c) the production of wastes.
(d) all the above

______ 17. The methods of agriculture used by humans have created serious insect problems, primarily because these methods

(a) increase soil erosion.
(b) provide concentrated areas of food for insects.
(c) increase the effectiveness of insecticides over a long period.
(d) decrease plant disease in a particular area.

______ 18. The one resource that consumers cannot do without is

(a) wind.
(b) soil.
(c) sunlight.
(d) food.

______ 19. Humans differ most significantly from other consumers

(a) because they use both plants and animals for food.
(b) in their ability to modify the environment.
(c) in their biotic potential.
(d) all the above

______ 20. Commodities that recycle at very slow rates are

(a) nonrenewable resources.
(b) not useful to people.
(c) renewable resources.
(d) both (a) and (b)

______ 21. Which of the following is considered a nonrenewable resource?

(a) sunlight
(b) water
(c) wind
(d) marble

______ 22. The removal from soils of minerals and organic matter is known as

(a) erosion.
(b) recycling.
(c) pollution.
(d) depletion.

______ 23. Energy that is available to us as a renewable resource is

(a) gas.
(b) coal.
(c) hydroelectric.
(d) oil.

______ 24. One of the negative aspects of hydroelectric power generation is

(a) power production.
(b) habitat destruction.
(c) flood control.
(d) a recreational lake.

______ 25. Electricity can be generated in a number of ways. Which way causes the least problems from an ecological point of view?

(a) coal
(b) hydroelectric
(c) nuclear
(d) geothermal

_____ 26. Many species of plants and animals are in danger of extinction today because

(a) people have hunted them to the point where they are endangered.
(b) people have destroyed the habitat of many endangered species.
(c) of changes in the earth's climate over the last 10 000 years.
(d) both (a) and (b)

_____ 27. Which of the following is not extinct?

(a) passenger pigeon
(b) dodo
(c) heath hen
(d) whooping crane

_____ 28. Which of the following has resulted in the greatest harm to the biosphere?

(a) erosion of soil
(b) forest fires
(c) people's lack of concern for the environment
(d) people's ability to prevent disease

_____ 29. The most common gases in the atmosphere are

(a) oxygen and carbon dioxide.
(b) carbon dioxide and water.
(c) nitrogen and ozone.
(d) nitrogen and oxygen.

_____ 30. The pH of rain is usually

(a) neutral.
(b) slightly acid.
(c) very acid.
(d) slightly alkaline.

_____ 31. Pollutants may be released into the atmosphere by

(a) vaporization.
(b) combustion.
(c) friction.
(d) all the above

_____ 32. The pollutant that affects the body's ability to take in oxygen is

(a) carbon monoxide.
(b) ozone.
(c) carbon dioxide.
(d) nitrogen oxide.

_____ 33. The two substances that contribute to the development of acid rain are

(a) ozone and particulates.
(b) carbon monoxide and hydrocarbons.
(c) nitrogen dioxide and sulphur dioxide.
(d) methyl mercury and tetraethyl lead.

_____ 34. Melting of the polar ice cap could result from

(a) air pollution due to sulphur dioxide.
(b) photochemical smog.
(c) the greenhouse effect.
(d) particulates in the air.

_____ 35. Lakes that are able to resist the effects of acid rain

(a) have basins of granite.
(b) have basins of limestone.
(c) are found in northeastern Alberta.
(d) are found in northern Ontario.

_____ 36. Which is the correct sequence of events in the hydrologic cycle in an ecosystem?

(a) precipitation → evaporation → condensation → precipitation
(b) evaporation → precipitation → condensation → evaporation
(c) precipitation → condensation → evaporation → precipitation
(d) condensation → evaporation → precipitation → condensation

_____ 37. Polluting water with sewage is harmful because

(a) the oxygen supply increases.
(b) the oxygen supply decreases.
(c) aerobic organisms increase.
(d) anaerobic organisms are killed.

_____ 38. Sewage containing nitrates and sulphates may cause a lake to die by

(a) magnification.
(b) exploitation.
(c) depletion.
(d) eutrophication.

_____ 39. The problem of solid waste management can be largely eliminated by

(a) recycling.
(b) use of open dumps.
(c) landfills.
(d) dumping refuse at sea.

_____ 40. Chlordane and dieldrin are

(a) automobile emission gases.
(b) wastes from nuclear power plants.
(c) industrial toxic wastes.
(d) insecticides.

_____ 41. Hearing loss can occur from continuous noise above

(a) 10 decibels.
(b) 25 decibels.
(c) 50 decibels.
(d) 80 decibels.

Part Two: Short Answer

1. What is the relationship between population size and resource conservation?

2. Give an example of how a waste may become a resource.

3. List five ways that you as an individual can help curb pollution and conserve resources.

4. Select a magazine or newspaper article on any aspect of the material you have covered in this lesson. Include the article in the lesson. Comment on the relevance of the article to you as a member of your community and province or country.

END OF LESSON 5

LESSON RECORD FORM

2230 Biology 20
Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ______________________

Time Spent on Lesson ______________________

(If label is missing
or incorrect)

File Number ______________________

Lesson Number ____________

FOR SCHOOL USE ONLY

Assigned Teacher: ________

Lesson Grading: ________

Additional Grading E/R/P Code: ________

Mark: ________

Graded by: ________

Assignment Code: ______

Date Lesson Received: ______________________

Lesson Recorded ______

Student's Questions and Comments

Apply Lesson Label Here

Name ______________________

Address ______________________

____

____

Postal Code ______________________

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____
Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

WILDLIFE MANAGEMENT: PREDATOR AND PREY RELATIONS

In 1975, a 300 square mile island forest reserve contained a population of about 3000 deer. The vegetation on the island was excellent, but wildlife management personnel feared that any further increase in the number of deer on the island would lead to overgrazing and mass starvation. Hunters found the island to be too remote and thus could not assist in the maintenance of the deer population. The wildlife service decided to introduce natural predators to the island in hopes that the weakest deer would be eliminated. This would keep the numbers of deer on the island in check and strengthen the quality of the herd. In 1976, 15 wolves were flown in to the island. The results of this natural predator program were as follows:

Table 1:

Year	Deer Population	Deer Offspring	Wolf Population	Predation	Deer Starvation	Population Change
1975	3000	1250	15	600	150	+500
1976	3500	1430	18	720	370	+340
1977	3840	1550	25	1000	750	−200
1978	3640	1506	34	1360	430	−284
1979	3356	1537	42	1680	36	−179
1980	3177	1314	37	1480	15	−181
1981	2996	1209	32	1280	0	−71
1982	2925	1143	28	1120	0	+23
1983	2948	1196	29	1160	0	+36
1984	2984	1217	29	1160	0	+57

Table 2: Age Structure of Herd in 1984

Age	No. of Deer
0 - 1	1295
1 - 2	516
2 - 3	390
3 - 4	252
4 - 5	158
5 - 6	130
6 - 7	103
7 - 8	84
8 - 9	63
9 - 10	9
Total	3000

Value **Conclusions and Application Questions**

③ 1. Graph the wolf and deer populations over the 10-year study period using the data provided in Table 1. Graph paper has been provided at the end of this lesson.

③ 2. Did the introduction of wolves to the island have a significant impact on the deer population in 1976? Explain why or why not.

____

____

____

____

____

② 3. List two ways in which the deer population could have been brought under control in a shorter amount of time.

(a) ______________________________

(b) ______________________________

③ 4. List three factors which limit a deer population.

(a) ______________________________

(b) ______________________________

(c) ______________________________

② 5. Explain why so many deer starved to death in 1977.

____

____

____

Value

② 6. The wolf population declined after 1979. Explain why.

② 7. Based on the data given, will the deer population ever reach the high of 1977 again with the wolves present on the island? Explain why or why not.

① 8. What would be the factor limiting or restricting the number of wolves on the island?

② 9. Wildlife officials decided to allow hunters to kill half the wolves on the island in 1988. What effect would this have on the deer population? Explain your answer.

Value

② 10. Suppose wildlife officials introduced 20 mountain lions onto the island in 1985. How would this effect the:

(a) deer population – ______________________

(b) wolf population – ______________________

③ 11. Use the data from Table 2 to graph the age distribution for the herd in 1984. Convert all numbers to a percentage of the total deer population, then graph the percentages.

② 12. Based on the data from Table 2, which stages in the life of a deer have the highest mortality? Explain why this is so.

③ 13. (a) What percentage of the population were fawns in 1984?

Value

(b) Suppose the percentage of fawns was 65%. What would that indicate about the growth of the herd? Would the population be increasing?

____

____

____

____

____

Please submit the entire lesson for correction.

END OF LESSON 6

LESSON RECORD FORM

2230 Biology 20
Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ____________________

Time Spent on Lesson ____________________

(If label is missing or incorrect)

File Number ____________________

Lesson Number ____________

FOR SCHOOL USE ONLY

Assigned Teacher: ________

Lesson Grading: ______

Additional Grading E/R/P Code: ______

Mark: __________

Graded by: _________

Assignment Code: _____

Date Lesson Received: ____________________

Lesson Recorded _____

Student's Questions and Comments

Apply Lesson Label Here

Name

Address

Postal Code

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____
Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

THE GENETIC CODE

Introduction

The science of heredity is called genetics. Your heredity consists of those traits you inherited from your mother and father. How is a trait, such as blue eyes, passed from one generation to the next? What determines if you will have your mother's nose, your father's nose or something in between? Why do mutations sometimes occur? These questions, and many others, will be answered in the next four lessons where an attempt will be made to examine and explain the mechanisms involved in heredity. The topic for the next four lessons, then, is **genetics**.

This first lesson in genetics will examine DNA (deoxyribonucleic acid), the compound responsible for the continuity of traits from one generation to the next. The Watson-Crick model of DNA structure will be reviewed, as well as the processes involved in DNA replication and protein synthesis. The importance of the DNA code will be examined as will the results of coding errors, i.e. **mutations**.

You will begin with a review of the chemical components which make up living organisms before going on to how these components can be passed on from generation to generation.

Materials for Life

All living things are composed of the same elements that are found in the nonliving world. Elements such as carbon (C), oxygen (O), hydrogen (H), nitrogen (N), phosphorus (P), and sulphur (S) account for almost 98 per cent of the atomic composition of human beings. It may seem surprising that these same elements also make up a large portion of the earth's atmosphere and crust (see Table 1). The difference, then, between living and nonliving things must be in the way the elements are combined and react with one another.

ELEMENT	SYMBOL	APPROXIMATE % (BY WEIGHT) OF A PERSON	APPROXIMATE % (BY WEIGHT) OF A CORN PLANT	APPROXIMATE % (BY WEIGHT) OF EARTH'S CRUST
Oxygen	O	65.	75.	49.
Carbon	C	18.	13.	0.09
Hydrogen	H	10.	10.	0.88
Nitrogen	N	3.3	0.45	0.03
Calcium	Ca	1.5	0.07	3.4
Phosphorus	P	1.0	0.06	0.12
Potassium	K	0.35	0.28	2.4
Sulfur	S	0.25	0.05	0.05
Sodium	Na	0.24	trace	2.6
Chlorine	Cl	0.19	0.04	0.19
Magnesium	Mg	0.05	0.06	1.9
Iron	Fe	0.005	0.03	4.7
Manganese	Mn	0.0003	0.01	0.08
Silicon	Si	trace	0.36	25.

Table 1: A Comparison of the Atomic Composition of a Person, a Corn Plant and the Earth's Crust

A. Inorganic Compounds

The materials which make up the abiotic (nonliving) environment are known as **inorganic compounds**. These compounds generally do not contain atoms of both carbon and hydrogen. Carbon dioxide (CO_2), water (H_2O) and calcium carbonate ($CaCO_3$) are all examples of inorganic compounds. They possess relatively simple chemical structures. Each molecule of water is composed of only three atoms; two atoms of hydrogen and one atom of oxygen (see Figure 1).

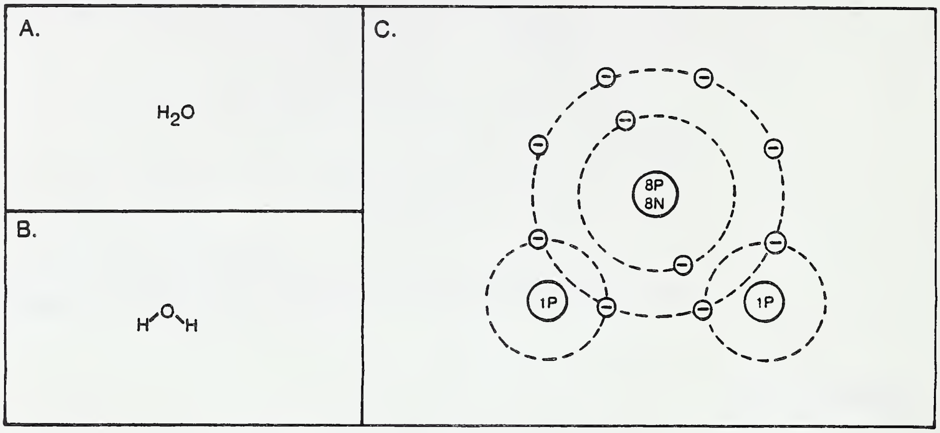


Figure 1: Various Representations of the Water Molecule: A. Molecular Formula; B. Structural Formula; and C. Bohr diagram.

Living organisms are basically composed of inorganic compounds. Water is the most abundant inorganic compound, forming between 65 and 95 per cent of the substance in every living thing. This means the majority of the substance in each living organism is no different than the nonliving things around it!

Inorganic compounds are necessary for life but they themselves do not account for the special chemical attributes which make up "living matter." The compounds which form the essence of living things are known as **organic compounds**.

B. Organic Compounds

Organic compounds are those substances responsible for the "living" properties of cells. These compounds all contain the element carbon and usually also hydrogen and oxygen. The organic compounds are what gives living things their complexity. Organic compounds generally have complex structures because of the chemical properties of carbon.

A carbon atom contains six electrons, four of which occupy the outer energy level. To form a stable compound, carbon requires eight electrons in its outer energy level. Carbon obtains these extra electrons by forming **covalent bonds** with other atoms (See Figure 2). These covalent bonds are represented in structural formulas by a straight line between the symbols of atoms. (Note that the structural formulas and Bohr diagrams are included for general information only and are not to be memorized.)

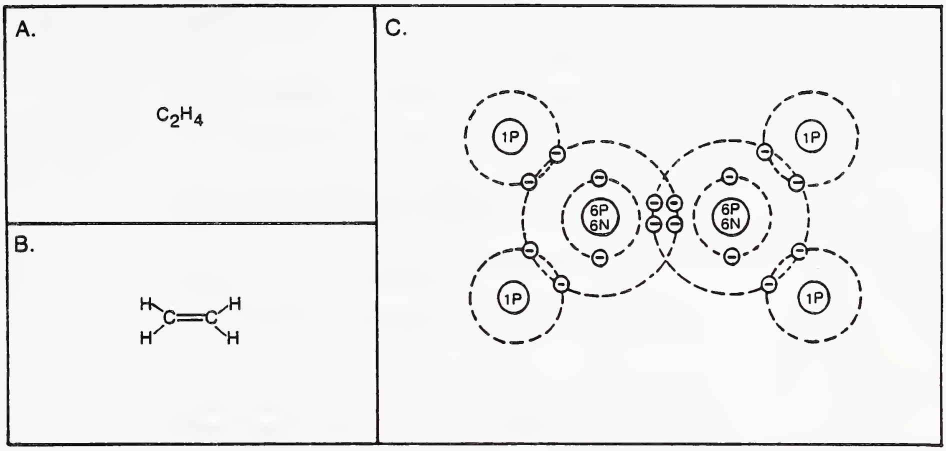
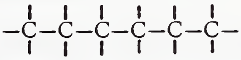


Figure 2: Covalent bonding in the organic compound, ethylene: A. Molecular formula; B. Structural formula; C. Bohr diagram showing electron sharing.

It is not by chance that carbon is the structural basis of organic compounds. Carbon has a number of physical properties which make it ideal for use in living things. The following is a list of a few of these properties.

1. Carbon atoms are able to join in series to form long carbon chains.



$$-C-C-C-C-C-C-$$

2. Carbon compounds do not dissolve easily in water. (This is important since living things are 65 to 95 per cent water).
3. Carbon compounds can be easily broken down, thus providing a good source of energy.

Cells contain hundreds of different groups of organic compounds. Of these, four groups are found in all types of cells and form the organic basis of living matter. These four groups of organic compounds include the carbohydrates, fats, proteins and nucleic acids.

READ

Read the sections of your text dealing with carbohydrates, fats and proteins (pp. 36 to 50).

Exercise 1: Materials for Life

Use the lesson notes and assigned readings to complete the following keyed exercise.

1. Complete each of the following statements by filling in the numbered blank on the right.

(a) C, is the chemical symbol for the element, __(1)__ . (1) __________

(b) Proteins are made of subunits called __(2)__ __(2)__ (two words). (2) __________ __________

(c) Glycerol combines with fatty acids to form a molecule of __(3)__ . (3) __________

(d) A disaccharide is formed by the joining of two __(4)__ . (4) __________

(e) The majority of every living thing is made up of the inorganic compound, __(5)__ . (5) __________

(f) The molecular formula for water is __(6)__ . (6) __________

(g) Of the four major groups of organic compounds (lipids, carbohydrates, proteins and nucleic acids), __(7)__ and __(8)__ are composed entirely of the elements; carbon, hydrogen and oxygen.

(7) __________

(8) __________

(h) __(9)__ , __(10)__ and __(11)__ are all examples of polysaccharides.

(9) __________

(10) __________

(11) __________

(i) __(12)__ are important in the growth, maintenance and repair of living material. (12) __________

2. Match the following by writing the letter of the item from the right hand column beside the statement on the left that best describes it. **Do not** use any letter more than once.

______ the process of splitting a molecule by adding water

______ complex carbon compounds found in living things

______ holds two amino acids together

______ the simplest type of carbohydrate

______ the process of building more complex molecules by removing water

______ material which makes up the abiotic environment

A. monosaccharide

B. hydrolysis

C. inorganic compounds

D. organic compounds

E. dehydration synthesis

F. peptide bond

G. disaccharide

3. Is common table salt (NaCl) an organic or inorganic compound?

____

Explain your answer.

____

____

____

Please check your work with the answers given on page 17.

Synthesis of Organic Compounds

Organic compounds allow for the level of complexity which permits life. Carbohydrates, lipids and proteins must all be synthesized by cells in order to provide the nutrients necessary to sustain life. Each of the organic compounds must be assembled to exacting specifications if the cell (and the organism) is to continue to function. Each animal cell contains more than 100,000 different proteins, and each protein usually contains at least 1,000 amino acids. The specific physical features or traits of each organism are based on the organic compounds present. How then, can all the instructions needed for the assembly of specific cellular compounds be passed from one generation to the next?

For years scientists knew that proteins were synthesized by the ribosomes in the cytoplasm of the cell. It was also known that the nucleus was the control centre for all cellular activities. The question was, what substance controlled the synthesis of organic compounds and how was this accomplished? The answers came with the discovery of the structure of nucleic acids, specifically the structure of **deoxyribonucleic acid (DNA).**

There are two basic types of nucleic acids found within each cell, DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). DNA is found almost exclusively within the nucleus of all eukaryotic cells. RNA can be found both within the nucleus and cytoplasm.

Chromosomal Structure

The chromosomes are the principal structures in the nucleus that are associated with heredity. Each chromosome is composed of deoxyribonucleic acid (DNA) and proteins. A complete set of chromosomes provides a complete set of instructions for the development of a cell and all its ancestors. In a normal cell, the genetic material exists as threadlike structures (chromatin) not easily distinguished from the rest of the nuclear material. However, when a cell starts to divide, the chromosomes shorten and thicken, making them easier to see and identify.

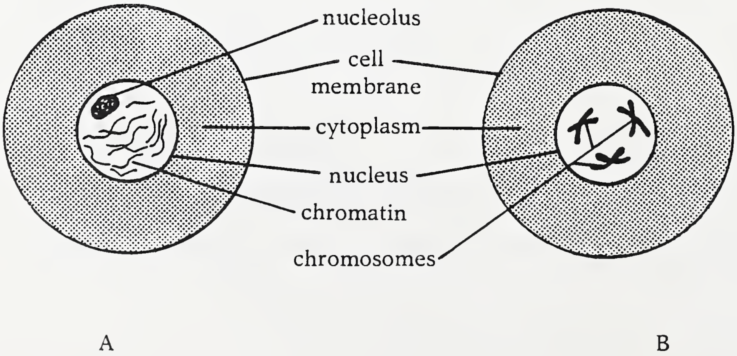


Figure 3: Showing (A) the normal cell with threadlike chromatin and (B) a cell with well-defined chromosomes, preparing to undergo cell division.

The Structure of DNA

READ

Read the section of your text dealing with the structure of DNA (pp. 53 to 55).

DNA is an extremely large, complex molecule composed of thousands of similar repeating units called **nucleotides**. In DNA each of these nucleotides is composed of three fundamental compounds; a monosaccharide called **deoxyribose,** a **phosphate** group and **one** of four **nitrogenous bases**. The four possible bases include **adenine, cytosine, guanine** and **thymine**. The four bases have the code letters **A, G, C** and **T.**

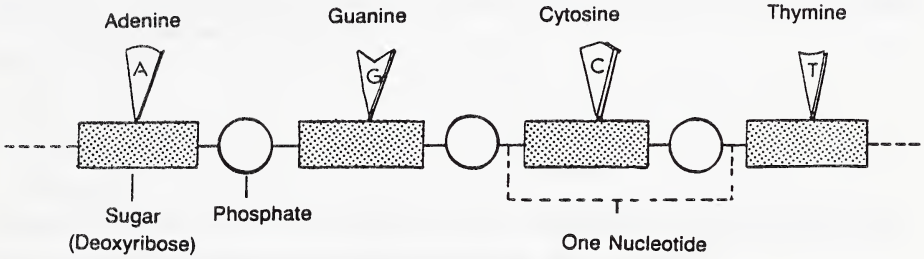
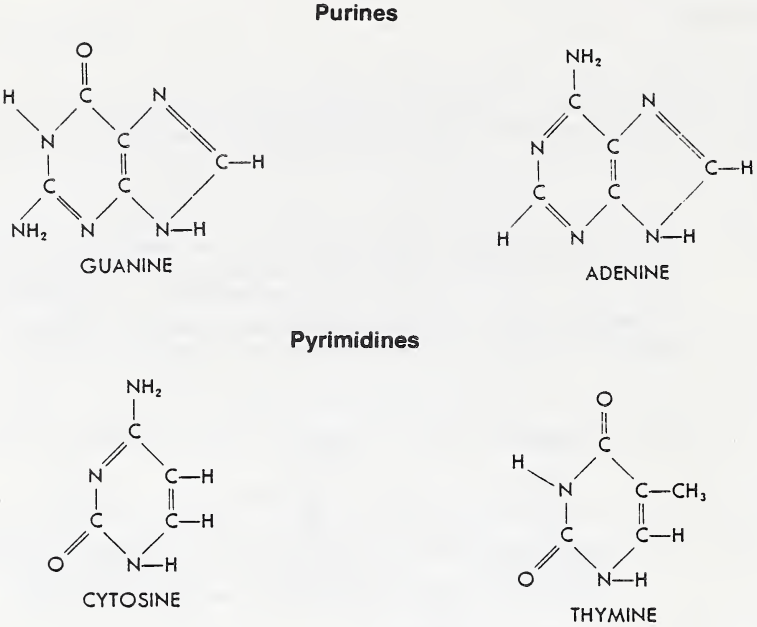


Figure 4: A small portion of a DNA molecule, showing the nucleotide units with different bases. (This is a simple diagrammatic representation.)

The nitrogenous bases found in nucleic acids can be divided into two major categories based on their three-dimensional structure. Those bases possessing a double-ring structure are called **purines** and those bases with only a single ring are called **pyrimidines**. The structural formulas for each of the nitrogenous bases are provided for your general knowledge and are not to be memorized.


Purines

GUANINE

ADENINE

Pyrimidines

CYTOSINE

THYMINE

Figure 5: The structural formulas of the four nitrogenous bases in DNA.

A. The Watson-Crick Model of DNA

Even though DNA is an extremely large molecule, composed of thousands of nucleotides, it is still too small to study its structure in detail. Scientists had known for some time that DNA was composed of phosphate groups, deoxyribose and nitrogenous bases, but no one knew how these components fit together. It was not until 1953, when James Watson and Francis Crick presented their model of DNA, that a satisfactory explanation for DNA structure was put forward. The following is a summary of the Watson-Crick model of DNA.

Each chromosome within the nucleus consists of a double parallel chain of DNA. The DNA strands are coiled, forming a spiral or helix. Since there are two strands in each chromosome, the structure is called a double helix.

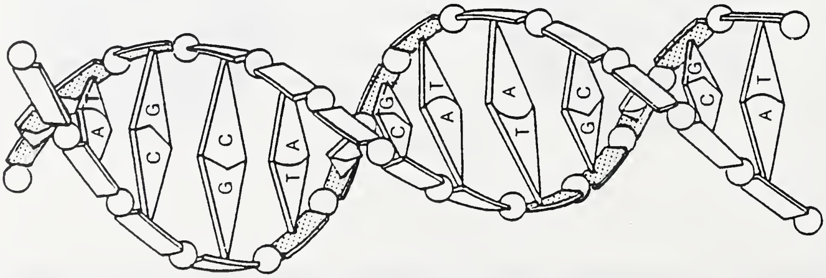


Figure 6: A small portion of a DNA molecule showing its double helix structure.

The nitrogenous bases of the nucleotides join to hold the two strands of DNA together. The bases always pair in a definite way; adenine always joins with thymine and guanine always joins with cytosine (notice that a purine always joins a pyrimidine). The bases join this way because they have complementary surface shapes which fit together much like the pieces in a jigsaw puzzle.

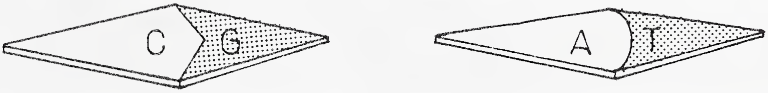


Figure 7: Purine-pyrimidine bonding of base pairs. Notice how the complementary surface shapes join each other.

Replication of DNA

READ

Read the section of your text dealing with the replication of DNA (pp. 55 and 56).

The Watson-Crick model of DNA is not only useful for determining structure but also for explaining the process of **replication**. Remember, DNA is the only organic compound capable of building an exact copy of itself! The process of replication is necessary if a cell is to divide and produce more cells. Replication allows the genetic code contained within the structure of DNA to be passed on, unchanged, from one generation to the next.

Replication begins with an unwinding of the double helix. The DNA molecule then ''unzips'' as the weak bonds between the nitrogenous bases break and the two strands separate. Individual nucleotides then unite with the exposed bases; adenine to thymine and guanine to cytosine. This continues until two duplicate molecules of DNA are formed. (See Figure 8). This entire process requires the presence of several enzymes and an energy source, ATP.

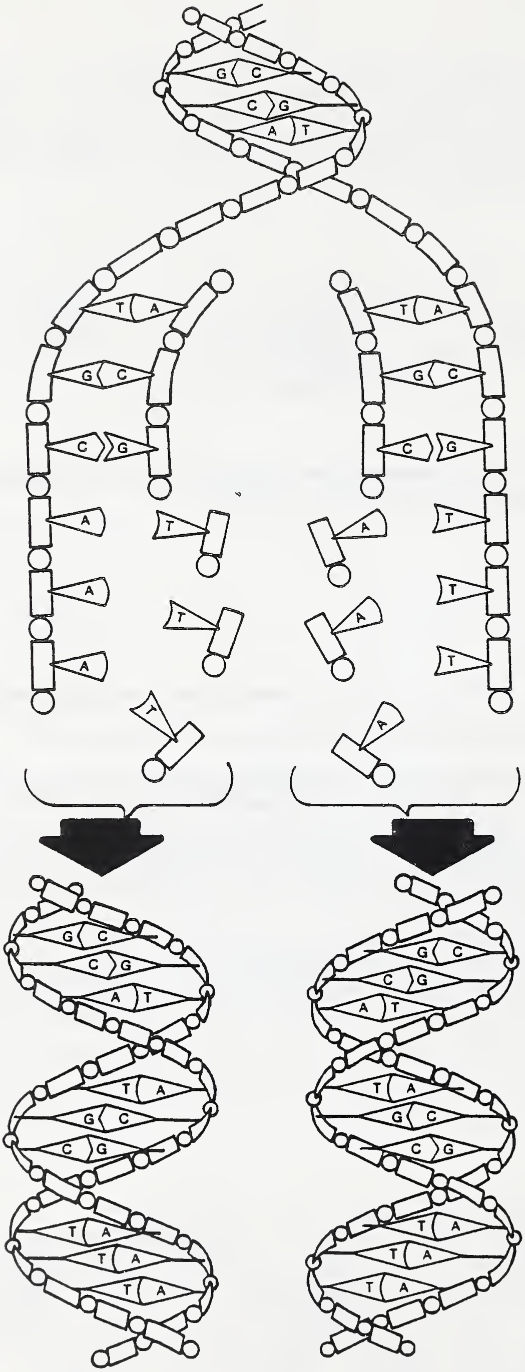


Figure 8: Replication of a DNA molecule. Notice that the two "new" DNA molecules have exactly the same sequence of bases.

The Genetic Code

READ

Read the section of your text dealing with translating the genetic code (p. 56). You may also want to review the section on proteins (pp. 44 to 50).

In order for a particular protein to perform its particular function in a cell, the amino acids must be placed in the same order each time a new molecule is made. There are thousands of combinations of the 20 basic amino acids possible, so the information about how to make each protein must be found somewhere in the cell.

The vast diversity of structure for the proteins is coded on the DNA located in the nucleus of the cell. This code is rather complex because DNA (the carrier of the data) and protein (the product made from the information) are made of very different substances. The order of the amino acids must be determined by the order of the bases on the nucleotides. How then, can the four kinds of bases in DNA, code for the 20 amino acids?

Only four amino acids could be produced if each was represented by a single base. Two bases in a row only allow for 16 combinations of the four bases. At least three bases in a row are needed then, to code for each of the 20 amino acids. The four bases in the DNA code may be arranged in 64 possible combinations of three bases in a row. Experiments have confirmed that three bases in a row are necessary to code for an amino acid. The three bases representing an amino acid are known as a **codon**.

One codon of DNA codes for one amino acid. One gene may consist of hundreds or thousands of codons, as many as are needed to synthesize a specific protein.

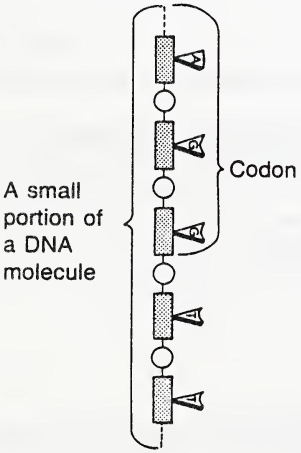


Figure 9: A diagrammatic representation of a codon, the basic unit of the gene.

Genes are units of heredity, transmitted from one generation to the next. There is no consensus as to the exact usage of the term but for our purposes a gene can be defined as **the segment of DNA that carries the code for a specific protein**.

The question then is, how is the DNA in the nucleus able to control the synthesis of proteins? Remember, protein synthesis takes place on the ribosomes which are located throughout the cytoplasm of the cell.

The answer lies with the introduction of the other type of nucleic acid, **RNA**.

RNA Structure

RNA (ribonucleic acid) is a large, complex molecule composed of similar repeating units called nucleotides. RNA is, however, quite small compared to DNA.

There are three major differences between the structures of RNA and DNA.

1. RNA is composed of a single strand of nucleotides.
2. The nucleotides in RNA contain the monosaccharide **ribose**.
3. RNA contains the pyrimidine **uracil**, instead of thymine.

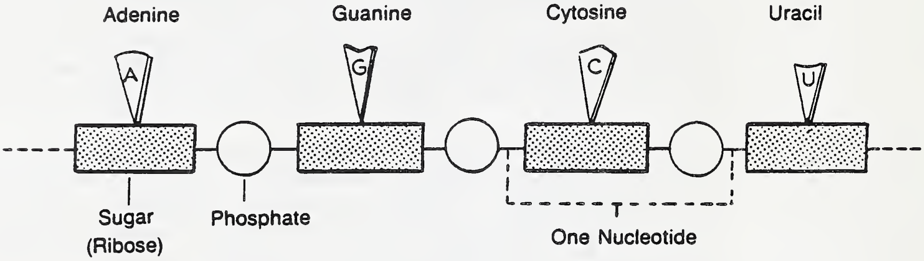


Figure 10: A diagrammatic representation of a portion of an RNA molecule.

RNA is found within both the nucleus and cytoplasm of a cell. It plays a major role in the transfer of information from DNA molecules within the nucleus, to ribosomes in the cytoplasm. RNA transfers coded information from the DNA molecule to the ribosome for the production of proteins. RNA also plays a major role in the production of proteins.

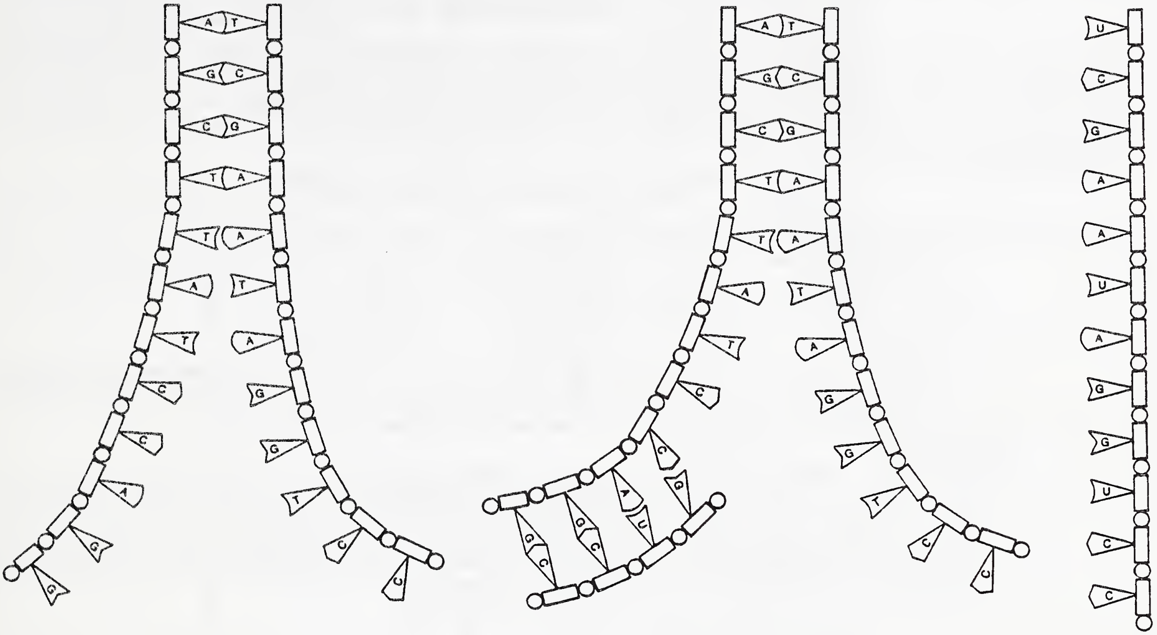
Protein Synthesis

Read the sections of your text dealing with RNA and protein synthesis (pp. 57 to 61).

A. Transcription

The process of transferring the genetic code from DNA to RNA is called **transcription**. This process takes place in the nucleus. DNA codons are transcribed into mRNA codons to facilitate protein synthesis.

Transcription can only occur when a molecule of DNA unwinds and partially "unzips", exposing its bases. RNA nucleotides match up with the appropriate DNA bases, forming a complementary strand of **messenger RNA (mRNA)**.



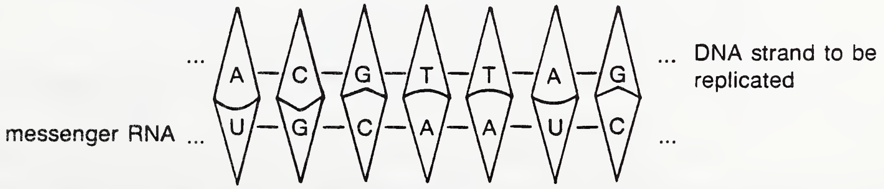
DNA OPENS

mRNA FORMS ON DNA

mRNA MOVES TO CYTOPLASM

Figure 11: Transcription: the transferring of the genetic code from DNA to mRNA for the purpose of protein synthesis.

Remember, the specific sequence of the bases in messenger RNA is determined by the sequence of DNA bases. As in DNA replication, only a specific RNA nucleotide may join with each DNA base. The following diagram illustrates this point.


... A C G T T A G ... DNA strand to be replicated
messenger RNA ... U G C A A U C ...

Once a strand of mRNA is completed, it breaks away from the DNA strand. This allows the two strands of DNA to rejoin and recoil to their original shape (a double helix). The mRNA strand then moves out of the nucleus and into the cytoplasm, where it becomes attached to a ribosome.

B. Translation

The major sites of protein synthesis in the cytoplasm are called **ribosomes**. Ribosomes are small structures composed of a combination of protein and a second type of RNA called **ribosomal RNA (rRNA)**. Ribosomes are most often found clustered together in the cytoplasm or along the endoplasmic reticulum. The ribosomes are structured to hold and manipulate the mRNA so the amino acids can be connected in the correct order. Look at the sequence of events in making a section of protein now that the code is ready to be translated; i.e. the mRNA is in place on the ribosome.

Before the amino acids can be assembled by the ribosomal machinery to make a protein they must be prepared in a special way. The amino acids are supplied with energy or ''activated'' before they can be joined to form a protein. But, you will recall that the amino acids must be placed in a particular order to form a particular protein. The ''activated'' amino acid cannot read the code so it is transported to the messenger RNA by a code-reading molecule.

The code-reading molecule is yet a third type of RNA called **transfer RNA (tRNA).** It is called ''transfer RNA'' because it picks up an ''activated'' amino acid and transfers it to the proper position on the messenger RNA.

Each amino acid is carried by a tRNA unique for it. Transfer RNA is a relatively small molecule, folded back and forth upon itself. The three-dimensional structure is often represented two-dimensionally as a cloverleaf. (See Figure 12.) Your text does not represent tRNA in this way. The cloverleaf structure of tRNA is shown here because it is the most widely accepted representation.

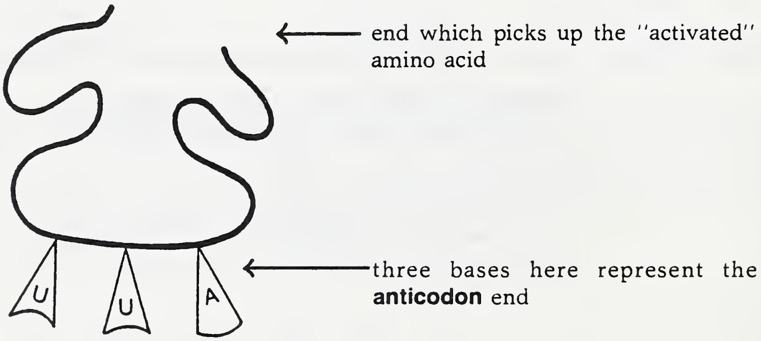

end which picks up the ''activated'' amino acid
U
U
A
three bases here represent the **anticodon** end

Figure 12: A two-dimensional representation of transfer RNA.

One end of the tRNA molecule combines with a specific amino acid. The other end of the tRNA molecule has a set of three exposed bases—the **anticodon**. Each type of tRNA has a different anticodon. This means that only one type of tRNA, carrying a specific amino acid, may combine with each codon of mRNA. This base-pairing mechanism for the union of tRNA and mRNA ensures that the arrangement of the amino acids will be the same as originally specified by the DNA code.

Protein synthesis begins when the ribosome moves along the mRNA molecule, bonding the appropriate tRNAs with each of the mRNA codons. The tRNA molecules and their amino acids are added to mRNA one by one to form a protein chain. As each tRNA comes into position on the mRNA molecule, its amino acid will bond to the adjacent amino acid in the chain.

When this occurs, the bond between the amino acid and the tRNA is broken. The tRNA then breaks away from the mRNA molecule and is free to pick up another amino acid. The continual addition of amino acids results in the formation of a protein chain. The completed protein breaks away from mRNA and is ready for use by the cell. The interaction of mRNA, tRNA, and ribosomes to form a protein is called **translation**. The following diagram illustrates the process.

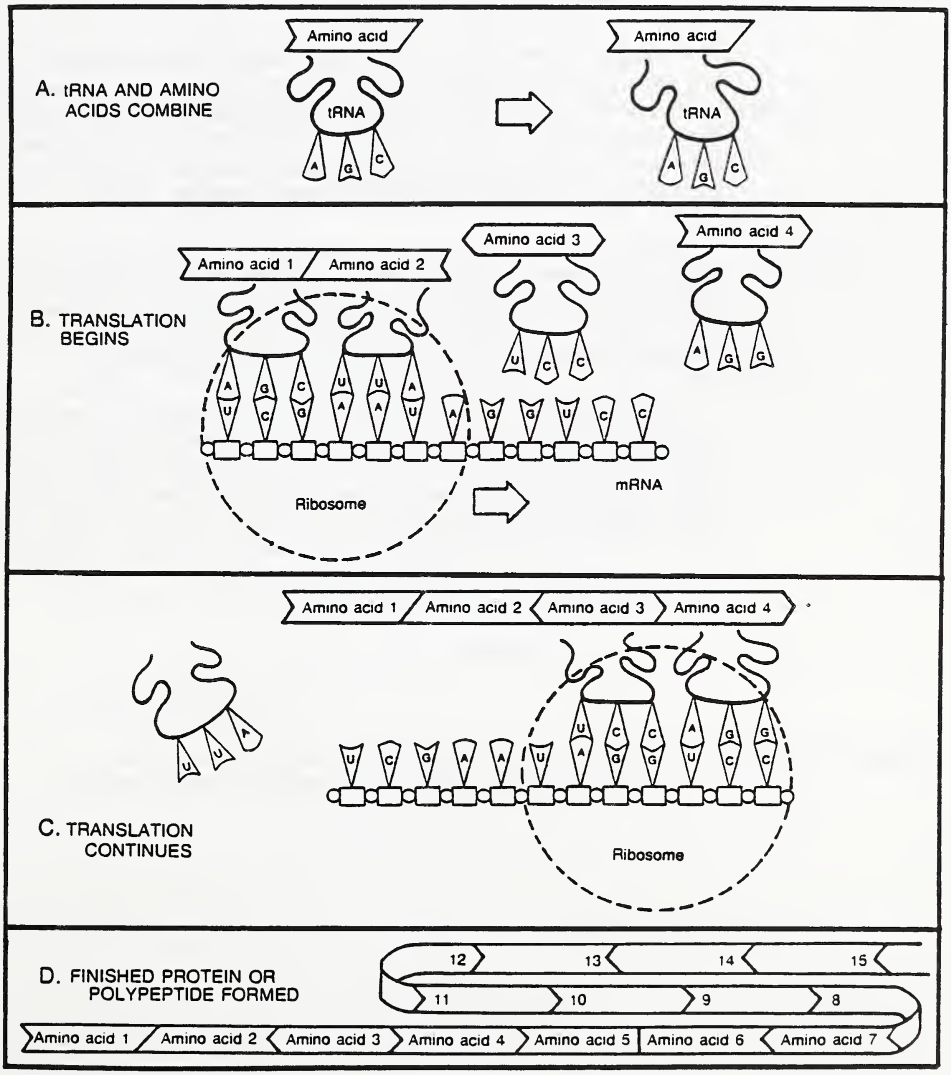


Figure 13: The process of translation. A: Specific amino acids combine with tRNA molecules. B: Transfer RNAs pair with the mRNA and the adjacent amino acids join. C: The tRNAs are released. D: The completed protein is released for use by the cell.

The mRNA molecule is not discarded after one protein is produced. Several copies of a protein can be made from one mRNA molecule before it eventually breaks down. This means that the DNA code need not be copied each time a protein is made.

Mutations

READ

Read the sections of your text dealing with genes and mutations (pp. 62 to 64).

Changes in genes are known as **mutations**. These are changes in the basic genetic code of a DNA molecule. Naturally, changes to the genetic code are not visible. A mutation can only be detected if it causes a visible change in an organism or its descendents. Ultra-violet light, X-ray radiation, high temperatures and a variety of chemicals are all known **mutagens** (mutation-producing agents). Mutations can be **induced** by the deliberate exposure of genetic material to a mutagen or they may be **spontaneous**, arising naturally.

Mutations may occur in the somatic (body) cells or in the reproductive cells of an organism. A somatic mutation may cause cancer in the individual possessing it, but this mutation will not be passed on to its offspring unless the organism reproduces by asexual means (mitosis or fission). A mutation in a reproductive cell may be passed on to the next generation and could have a pronounced effect on a population.

Most mutations that cause a visible change in an organism are harmful and often lethal, killing the individuals possessing them. A few mutations, however, may actually provide the individual with an advantage in survival and/or reproduction. Beneficial mutations, which can be inherited, may become permanent fixtures in the genetic code of future generations. These changes in the genetic code are the only source of "new" genetic material in a population and thus are important in continually adapting the population to its environment.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, p. 4.

1. Complete the statements with the words given below.

(1) **carbon**
(2) **amino acids**
(3) **fat**
(4) **monosaccharides**
(5) **water**
(6) **H_2O**
(7) **carbohydrates**
(8) **lipids**
(9) **starch**
(10) **cellulose**
(11) **glycogen**
(12) **Proteins**

2. Match the statements with the items given on the right.

B the process of splitting a molecule by adding water
D complex carbon compounds found in living things
F holds two amino acids together
A the simplest type of carbohydrate
E the process of building more complex molecules by removing water
C material which makes up the abiotic environment

A. monosaccharide
B. hydrolysis
C. inorganic compounds
D. organic compounds
E. dehydration synthesis
F. peptide bond

3. Is common table salt (NaCl) an organic or inorganic compound?

inorganic

Explain your answer.

Salt is an inorganic compound because it does not contain the element, carbon, which is present in all organic compounds.

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

For each of the following questions, choose the best answer and write the appropriate letter in the blank provided.

_____ 1. Carbon is a very important component of molecules in living cells because of its ability to

(a) ionize and react with water.
(b) dissolve easily in water.
(c) remain stable and not undergo chemical change.
(d) bond with four other atoms and form long carbon chains.

_____ 2. Those substances responsible for the "living" properties of cells are known as

(a) inorganic compounds.
(b) organic compounds.
(c) nucleic acids.
(d) proteins.

_____ 3. Which statement, comparing the chemical substances found in a rock with those found in a bean plant, is **true**?

(a) The substances are completely different.
(b) The substances are the same and are combined in the same way.
(c) The elements in both are the same but the amount of each element varies.
(d) The elements in both have the same names but are chemically different.

_____ 4. Proteins are composed of simpler units called

(a) amino acids.
(b) fatty acids.
(c) nucleotides.
(d) monosaccharides.

_____ 5. Organic molecules always contain at least

(a) carbon.
(b) oxygen.
(c) carbon and nitrogen.
(d) hydrogen and nitrogen.

_____ 6. Common table sugar (sucrose) would belong to the subgroup of carbohydrates known as

(a) monosaccharides.
(b) disaccharides.
(c) polysaccharides.
(d) triglycerides.

_____ 7. The process of splitting a molecule by adding water is known as

(a) dehydration synthesis.
(b) hydrogenation.
(c) respiration.
(d) hydrolysis.

_____ 8. Those fatty acids which possess one or more double bonds between their carbon atoms are called

(a) amino acids.
(b) saturated fatty acids.
(c) unsaturated fatty acids.
(d) nucleic acids.

_____ 9. Most of the nucleic acid making up the chromosomes is

(a) ADP.
(b) ATP.
(c) DNA.
(d) RNA.

_____ 10. Which bases would **NOT** pair with each other?

(a) adenine - thymine
(b) uracil - adenine
(c) guanine - cytosine
(d) thymine - cytosine

_____ 11. A DNA molecule "unzips" and is replicated. Choose the sequence of bases that would be formed to match the following piece of DNA.

A — G — T — T — C — G — A

(a) T — A — C — C — G — A — T
(b) T — C — A — A — G — C — T
(c) U — C — A — A — G — C — U
(d) U — T — C — C — G — T — U

_____ 12. Which statement is **NOT** true of the Watson-Crick model of DNA?

(a) Chromosomes consist of two strands of DNA molecules.
(b) DNA strands can separate into two polynucleotide molecules.
(c) Proteins are the chemical units making up DNA.
(d) The two strands of DNA form a double helix structure.

_____ 13. A nucleotide unit does not contain a

(a) peptide.
(b) base.
(c) phosphate.
(d) sugar.

______ 14. The nitrogenous base found in RNA but **NOT** in DNA is

(a) adenine.
(b) guanine.
(c) thymine.
(d) uracil.

______ 15. The sugar found in DNA but **NOT** in RNA is

(a) ribose.
(b) deoxyribose.
(c) galactose.
(d) glucose.

______ 16. Messenger RNA is made in the

(a) cytoplasm.
(b) nucleus.
(c) ribosome.
(d) mitochondria.

______ 17. **After** it is formed the messenger RNA becomes closely associated with the

(a) ribosomes.
(b) chromosomes.
(c) nuclear membrane.
(d) endoplasmic reticulum.

______ 18. If the following represents a DNA strand, choose the messenger RNA that would be formed from it.

A — C — T — G — G — T — A — C

(a) T — G — A — C — C — A — T — G
(b) T — C — A — G — G — A — T — C
(c) U — C — A — G — G — A — T — C
(d) U — G — A — C — C — A — U — G

______ 19. The role of transfer RNA in protein synthesis is to

(a) transport mRNA from the nucleus to the cytoplasm.
(b) attach mRNA to the ribosomes.
(c) carry amino acids to the correct site on the mRNA.
(d) synthesize the ribosomes.

______ 20. If the three bases on a section of tRNA carrying the amino acid valine are CAA, then the mRNA base sequence that codes for valine is:

(a) GUU
(b) CAA
(c) GTT
(d) TGG

_____ 21. How many DNA nucleotides would be involved in the coding of a polypeptide chain 12 amino acids long?

(a) 12
(b) 18
(c) 24
(d) 36

Use the following information to answer the next question.

Base sequence on mRNA	Amino acid
AAG	lysine
AUC	isoleucine
AGC	serine
UAC	tyrosine
UUC	phenylalanine
UGC	cysteine

_____ 22. Determine the amino acids and the sequence in which they are joined if the sequence of bases on a strand of DNA were: T—C—G—A—A—G—A—T—G

(a) tyrosine, lysine, lysine
(b) phenylalanine, lysine, serine
(c) serine, phenylalanine, tyrosine
(d) tyrosine, lysine, isoleucine

_____ 23. The three bases on the end of the tRNA molecule are called the

(a) codon.
(b) anticodon.
(c) messenger.
(d) activation site.

_____ 24. Any permanent change in one or more genes in a body cell of an organism is known as a

(a) somatic mutation.
(b) reproductive mutation.
(c) malignant tumor.
(d) benign tumor.

______ 25. Which of the following would **NOT** be considered a mutagen?

(a) ultraviolet light
(b) high temperatures
(c) low temperatures
(d) X-ray radiation

Part Two: Matching and Fill in the Blanks

1. Match the following by choosing the correct letter from Column II and placing it in the appropriate blank in Column I. Do **NOT** use any letter more than once.

	Column I		**Column II**
______	a nitrogenous base found only in DNA	A.	nucleotide
______	the sugar found only in RNA	B.	ribose
______	a nitrogenous base found only in RNA	C.	thymine
______	the sugar found only in DNA	D.	guanine
______	the nitrogenous base which would pair up with guanine	E.	adenine
		F.	uracil
______	the basic repeating unit of nucleic acids	G.	deoxyribose
______	combines with DNA to form chromosomes	H.	cytosine
		I.	protein
		J.	phosphate

2. Complete each of the following statements by filling in the numbered blank on the right.

(a) The science of heredity is called ___(1)___ . (1) ______________

(b) ___(2)___ is the most abundant inorganic compound found in living things. (2) ______________

(c) Carbon atoms are able to complete their outer energy level by forming ___(3)___ bonds with other atoms. (3) ______________

(4) ______________

(d) ___(4)___ , ___(5)___ and ___(6)___ are all examples of monosaccharides. (5) ______________

(6) ______________

(e) ___(7)___ and ___(8)___ are polysaccharides which are used for energy storage in living organisms.

(7) ____________________

(8) ____________________

(f) Each amino acid is made up of the elements; carbon, hydrogen, oxygen and ___(9)___ .

(9) ____________________

(g) There are ___(10)___ different amino acids that make up most proteins.

(10) ____________________

(h) Exact copies of any DNA molecule can be produced through a process called ___(11)___ .

(11) ____________________

(i) A ___(12)___ is a sequence of three bases which codes for the production of an amino acid.

(12) ____________________

(j) A ___(13)___ is the segment of DNA that carries the code for a specific protein.

(13) ____________________

(k) The process of transferring the genetic code from DNA to RNA is called ___(14)___ .

(14) ____________________

(l) The ___(15)___ are the major sites of protein synthesis in the cytoplasm.

(15) ____________________

3. The following is a summary of the events which take place in protein synthesis. These statements are listed in a random order. Indicate the proper sequence of events by placing a **1** in the blank in front of the first event, a **2** by the second event, and so on.

_____ the two strands of DNA rejoin and recoil

_____ the adjacent amino acids link up through a series of dehydration syntheses reactions

_____ tRNAs in the cytoplasm chemically bond to the different amino acids

_____ a completed strand of mRNA breaks away from the DNA strand

_____ RNA nucleotides match up with the appropriate DNA bases to form a strand of mRNA

_____ the completed protein breaks away from the mRNA molecule and is ready for use by the cell

______ the tRNA carrier is released from the mRNA and is free to pick up another amino acid

______ the DNA molecule unwinds and partially unzips, exposing its bases

______ after several proteins are produced the mRNA molecule breaks down

______ the mRNA molecule becomes attached to a ribosome

______ the ribosome moves along the mRNA molecule, bonding the correct tRNA anticodon to each of the mRNA codons

______ the mRNA molecule moves out of the nucleus, into the cytoplasm

4. A DNA strand reads G—T—C—C—G—A—A—C—A.

(a) What mRNA strand would be produced?

____

(b) What amino acids are encoded by this strand of mRNA? (Refer to Table 4-1 in your text, page 58, for the genetic code of mRNA.)

____

Part Three: Short Answer

1. Flying vertebrates, such as birds, store their energy in the form of fats instead of carbohydrates. Explain the advantages birds gain from this adaptation.

____

____

____

____

____

____

2. Why can a single change in primary structure affect the function of a protein?

____

____

____

____

____

____

3. Briefly explain why an amino acid could not be coded for by 2 nucleotides.

____

____

____

____

____

____

4. A child is born with six fingers on the left hand. Can this mutation be passed on to future offspring?

____

Explain your answer.

____

____

____

____

Please submit pages 18 to 25 for correction.

END OF LESSON 7

LESSON RECORD FORM

2230 Biology 20
Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ____________________

Time Spent on Lesson ____________________

(If label is missing
or incorrect)

File Number ____________________

Lesson Number ____________________

FOR SCHOOL USE ONLY

Assigned Teacher: __________

Lesson Grading: __________

Additional Grading E/R/P Code: __________

Mark: __________

Graded by: __________

Assignment Code: __________

Date Lesson Received: __________

Lesson Recorded __________

Student's Questions and Comments

Apply Lesson Label Here

Name ____________________

Address ____________________

____

____

Postal Code ____________________

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____
Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

MITOSIS AND MEIOSIS

Introduction

This lesson will examine the two processes that ensure a proper separation of chromosomes during cell division and reproduction—mitosis and meiosis. The four stages of mitosis will be reviewed in relation to the overall cell cycle, which also includes interphase and cytokinesis. The importance of mitosis and its role in asexual reproduction will also be examined.

Sexual reproduction depends on meiosis for the production of gametes. The stages of meiosis will be reviewed and the differences between meiosis in males and females will be examined and explained. This lesson will examine the importance of meiosis in maintaining chromosome numbers. The results of abnormal meiotic divisions will also be discussed.

The lesson begins with a discussion of the limits to cell growth and why cells divide. This will lead to an analysis of cell division and mitosis.

Limits to Cell Growth

The cell is the basic unit of life. All living things are made up of microscopic cells, each averaging about eight microns in diameter. The difference in size between an elephant and a mouse is not due to a difference in cell size, but rather a difference in the number of cells each organism has. Elephants are larger than mice because elephants have more cells.

Why are all cells about the same size? What, if anything, prevents cells from becoming larger? Why are cells generally microscopic in size? The answer to these questions lies in the ratio of the cell's surface area (cell membrane) to its volume. The cell membrane must provide the surface area required for an adequate exchange of oxygen, carbon dioxide, nutrients and wastes between the cell and its surroundings. As a cell grows, its volume increases more rapidly than its surface area. If the cell becomes too large its surface area will be too small for an adequate exchange of materials. Large cells would die because of a buildup of wastes within the cell and an inadequate supply of oxygen and nutrients.

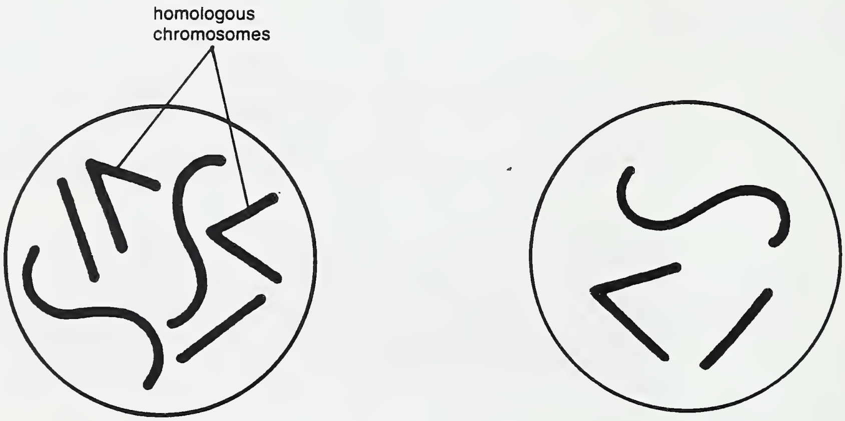
To prevent death because of continuous growth, most cells divide once they reach a certain size. Cell division produces two smaller cells, each about half the size of the original cell. This increases the *surface area to volume ratio* for each "new" cell and allows for additional growth by these cells.

Chromosomes and Chromosome Number

In the previous lesson we learned that the chromosomes are the principal structures associated with heredity. All traits passed from one generation to the next are coded and stored within the DNA of the chromosomes. With the exception of a few special types, cells within a living organism contain the same number of chromosomes. The chromosomes control the activities of each cell by providing the information necessary for the formation of all the required enzymes. Enzymes are the catalysts of the reactions which occur within the cell. Without DNA, the cell is unable to grow, make repairs or reproduce. In humans, mature red blood cells lack an organized nucleus and DNA. These cells are able to transport gases (oxygen and carbon dioxide) throughout the body, but soon deteriorate and die because of the lack of nuclear material. Therefore, the DNA within each cell must be duplicated whenever cell division occurs, with each cell receiving a complete set of instructions (DNA) once cell division is complete. This will ensure that each cell produced during cell division will have a complete and identical set of chromosomes.

What is the proper number of chromosomes for a cell? In humans, the somatic (body) cells each contain 46 chromosomes. A relative of the lobster contains 200 chromosomes in each cell and the fruit fly, *Drosophila*, has only 8 chromosomes in each somatic cell. The proper number of chromosomes, then, can vary with each species.

Regardless of the number of chromosomes in each somatic cell, each chromosome has an identical or matching chromosome. These identical chromosomes are called **homologous chromosomes**. Homologous chromosomes are similar in size and shape. They also carry genetic information for the same traits such as eye color or hair color. Cells which contain homologous pairs of chromosomes are known as **diploid** cells. Diploid cells contain a diploid number (2n) of chromosomes, that is, **two complete sets of chromosomes**. (See Figure 1.) The sex cells (gametes) are said to have the **haploid** (n) or monoploid number of chromosomes because they only possess **one copy of each type of chromosome** present in the adult.



diploid number (2n) in a body cell (2n = 6)

haploid number (n) in a sex cell (n = 3)

Figure 1: Diploid and Haploid Cells

In humans, for example, body cells have 46 chromosomes and sex cells have 23 chromosomes. This can be expressed as 2n = 46 and n = 23. Body cells of cattle have 60 chromosomes (2n = 60 and n = 30) while garden peas have 14 chromosomes (2n = 14 and n = 7).

Cell Division

READ

Read the sections of your text dealing with cell division (pp. 81 to 83).

Cell division is the process by which cells reproduce. During cell division one cell divides to produce two daughter cells, each about half the size of the original cell. You will now study some of the reasons cells divide.

One of the reasons for cell division has already been discussed. Cells divide to maintain a favorable *surface area to volume ratio*. Single-celled organisms also undergo cell division to produce offspring. When a single-celled organism divides, two "new" individuals are produced (See Figure 2). The production of new individuals by cell division is one method of asexual reproduction.

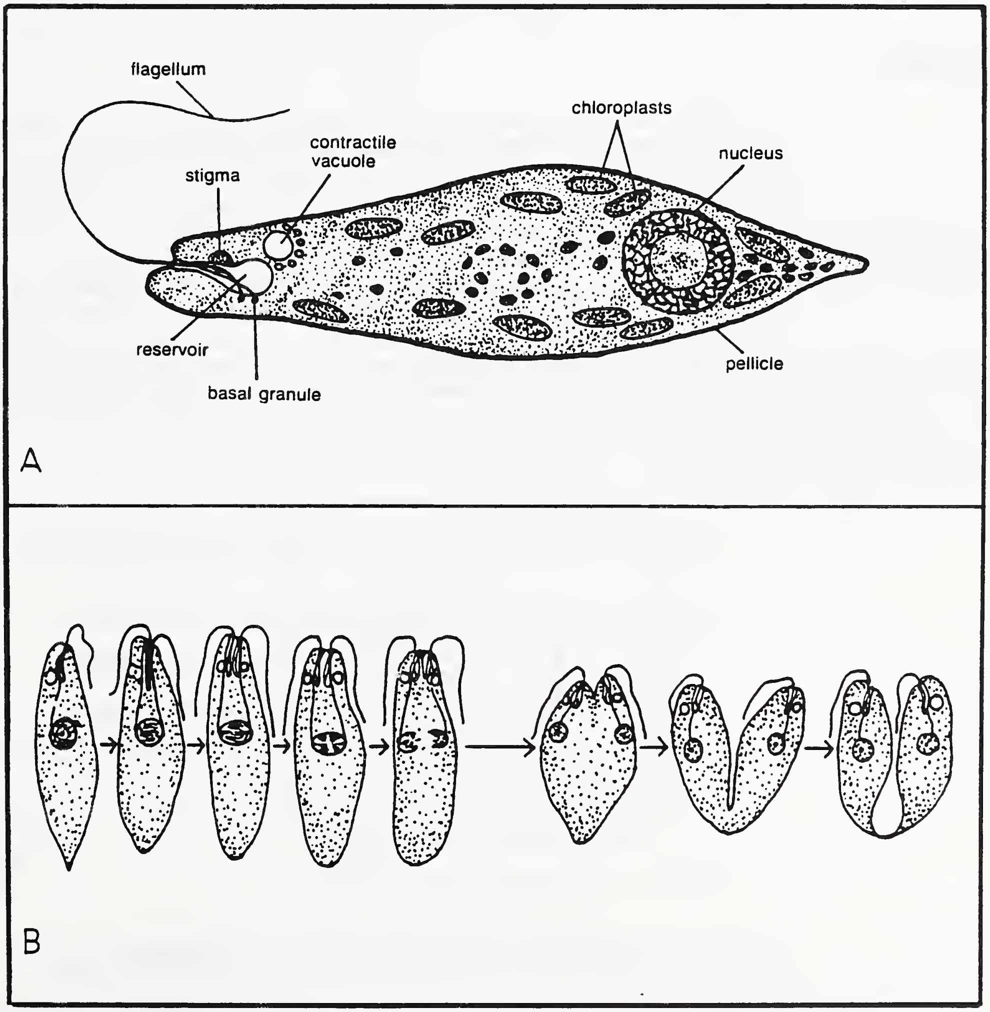


Figure 2: A: Structure of a free-living protozoan, euglena. B: Stages in the process of cell division in euglena.

Cell division is also required by multicellular organisms to replace dead or dying cells. Most multicellular organisms begin life as a single cell. This means that numerous cell divisions will be required for the growth and development of the organism.

There are two basic cell types which undergo cell division—prokaryotic and eukaryotic cells. **Prokaryotic cells are cells that lack a nucleus.** The genetic material, usually DNA, is found scattered throughout the cytoplasm of the cell. **Eukaryotic cells are cells that possess an organized nucleus which contains all of the hereditary material.** The vast majority of living things are made up of eukaryotic cells. Therefore, this course will concentrate on cell division in eukaryotic cells.

Interphase

Those eukaryotic cells not actively engaged in the process of cell division are said to be in the portion of the cell cycle known as *interphase*. Interphase has also been called the "resting stage" because there is little visible activity occurring within the cell. Actually, the cell is doing anything but resting! During interphase the cell is actively producing materials such as nucleic acids and proteins for the continued growth and repair of the cell.

In general, cells in interphase have a nucleus which is surrounded by a nuclear membrane and contains a nucleolus (or nucleoli) and chromosomes in the form of chromatin material. Chromatin material is spread throughout the nucleus as a network of fine invisible threads. Animal cells also have a **centriole** located just outside the nuclear membrane. The centriole seems to play a role in the movement of chromosomes during cell division.

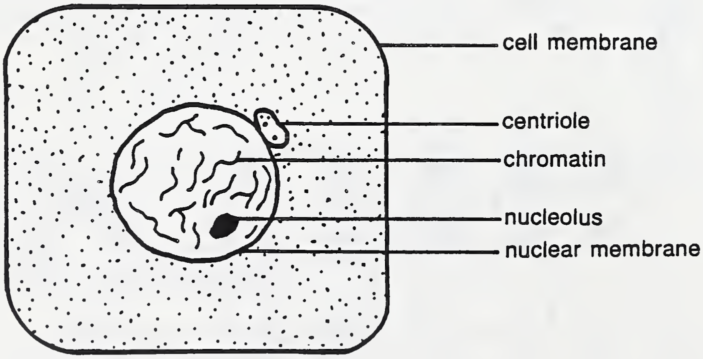


Figure 3: A generalized animal cell during the interphase stage.

Cells spend approximately 90 per cent of their lifetime in the interphase stage. Near the end of interphase the replication of DNA occurs. This replication of DNA is not a visible process because the genetic material is still in threadlike form as chromatin material. The replication of DNA means that the cell is now ready to proceed with cell division.

NOTE: Your text separates interphase into an S phase and a G phase. These subdivisions of interphase are beyond the scope of this course and need not be studied.

Mitosis

READ

Read the section of the text dealing with mitosis (pp. 83 to 85).

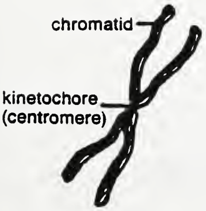
Mitosis is the first of two stages of cell division in eukaryotic cells. It is important to remember that the term **mitosis refers only to the separation of the chromosomes during cell division**. Division of the cytoplasm and its contents is a process known as cytokinesis. Cytokinesis is the second stage of cell division.

Mitosis can be observed in any dividing cell with the aid of a light microscope. Mitosis has been arbitrarily divided into four stages in order to simplify the discussion and the detailed study of the process. The four stages of mitosis include: *prophase, metaphase, anaphase* and *telophase*. The point at which one stage ends and the next begins is somewhat arbitrary because mitosis is actually a continuous process with no distinct pauses or gaps to define the stages.

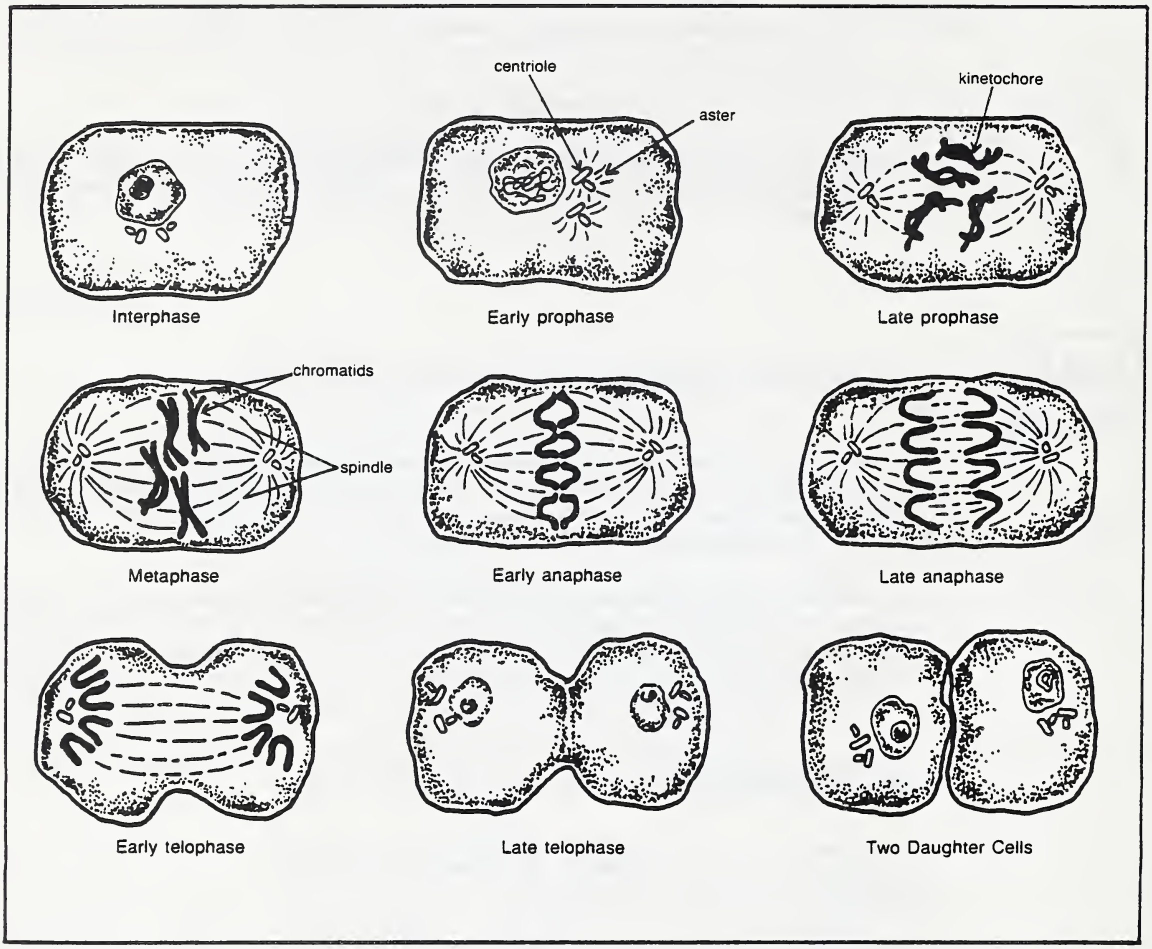
The events which occur during each stage of mitosis are discussed in your text (pp. 83 to 85). The following is a summary of the process of mitosis.

Table 1: Summary of Cell Division

Phase	Major Events
Interphase	- chromosomes replicate
Prophase	- chromosomes shorten and thicken - the two chromatids of each chromosomes are connected at the kinetochore (centromere) - the nuclear membrane and the nucleolus disappear in late prophase - the spindle forms between the poles
Metaphase	- chromosomes align along the equator of the cell
Anaphase	- kinetochores divide and each chromatid is now called a chromosome - chromosomes separate and move to opposite poles
Telophase	- nuclear membrane and nucleoli form - spindle dissolves - chromosomes become longer and thinner - cytokinesis begins, leading to the division of the cell into two daughter cells - both daughter cells are diploid (2n) as was the parent cell



A chromosome before separation of chromatids



Interphase
Early prophase
Late prophase
Metaphase
Early anaphase
Late anaphase
Early telophase
Late telophase
Two Daughter Cells

Figure 4: The phases of mitosis in an animal cell.

Cytokinesis

READ

Read the section of your text dealing with cytokinesis (pp. 85 and 86).

Cytokinesis completes the process of cell division by dividing the cytoplasm and its contents into the two daughter cells. This process starts during telophase and continues on, after the new nuclei are formed, to divide the original cell into two daughter cells. The division of the original cell occurs by two methods. A *cleavage furrow* forms between the two dividing parts in animal cells whereas a *cell plate* forms in plant cells to complete cell division. Animal cells also possess centrioles and the associated asters which migrate to the poles during prophase. Plant cells do not contain centrioles or asters.

At the end of cell division, the daughter cells contain the same genetic information as the parent cell. The daughter cells contain the diploid number of chromosomes as did the parent cell.

Meiosis

READ

Read the sections of your text dealing with meiosis (pp. 86 to 88).

Meiosis occurs in sexually reproducing organisms and involves the manufacture of gametes (sperm and eggs) in animals and spores in plants. In animals, this process usually takes place in special reproductive organs. During meiosis, the chromosome number is reduced from 2n to n. It is essential that the gametes be reduced to (n) so that when there is a union of sperm and egg, the normal chromosome number (2n) is restored. If a reduction in the number of chromosomes did not take place each time fertilization occurred, the chromosome number would double and redouble eventually approaching infinity. Study the following example.

Example

In humans the normal chromosome number is 46 or 2n = 46. Suppose meiosis did not occur in sex cells. The first generation offspring would contain 92 chromosomes, the second generation offspring would have 184 chromosomes and the tenth generation offpsring would have 94 208 chromosomes. As you can see, an infinite number of chromosomes would occur after many more generations. To compensate for this phenomenon, gametes are formed by meiosis so that the number of chromosomes in each gamete is reduced by one-half from 2n to n or as in the example, from 2n = 46 to n = 23.

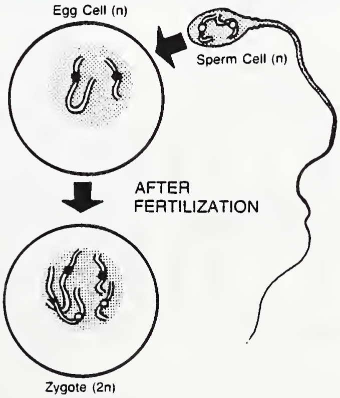


Figure 5: Sexual reproduction, showing the union of two haploid (n) gametes to form one diploid (2n) zygote.

Meiosis is somewhat more complicated than mitosis because there are two divisions, each one with the same basic stages as in mitosis. In the first division, the diploid number is reduced to the monoploid number. The second meiotic division separates the chromatids of the duplicated chromosomes.

Before going on to a discussion of the meiotic divisions, a review of the definition of homologous chromosomes is in order. A homologous pair of chromosomes can be described as two chromosomes similar in shape and size, which carry the same type of genetic information.

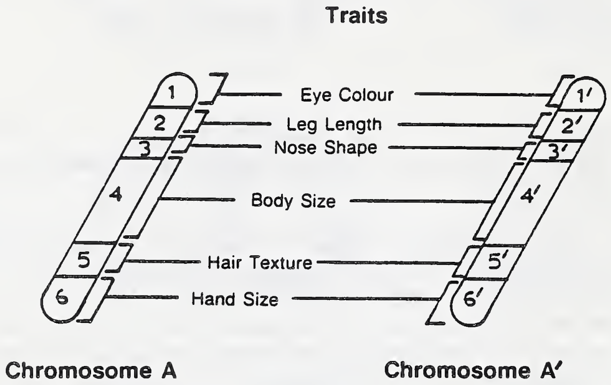


Figure 6: Model of a homologous pair of chromosomes (Chromosome A is formed from one parent while Chromosome A′ is formed from the other parent.)

It is important to understand that the actual traits expressed by each pair of chromosomes are not necessarily the same. On Chromosome "A" trait 4 may be carrying the type of genes which code for a large body frame while on chromosome "A′" trait 4′ may be carrying the type of genes which code for a small body frame. Each site on each chromosome is responsible for a general category, such as body size.

A. Meiosis I: The First Cell Division

Review the section of your text which deals with the first cell division of meiosis (pp. 86 to 88).

The following table is a summary of the events which take place during meiosis I. You may also wish to refer to the diagram of meiosis on this page.

Table 2: Meiosis I: The First Cell Division

Phase	Major Events
Interphase I	- chromosomes replicate
Prophase I	- chromosomes shorten and thicken - the nucleolus and the nuclear membrane break down - in animal cells, the centrioles migrate to the poles and the spindle forms - homologous duplicated chromosomes pair up with each other in a process called synapsis to produce a tetrad (four chromatids)
Metaphase I	- tetrads align along the equator of the cell - homologous chromosomes line up opposite each other on the equator
Anaphase I	- the pairs of homologous chromosomes separate and move towards the poles - the kinetochore does not divide so each chromosome consists of two chromatids
Telophase I	- one set of duplicated chromosomes accumulates at each pole - cytokinesis starts and the cell divides

At the end of this division, the number of chromosomes is reduced to the haploid number from the diploid number as there is only one set of chromosomes per cell. Each chromosome is usually still doubled, consisting of two chromatids or sister chromatids. These may separate in the first division but as a rule do not. The next division usually occurs without a resting stage.

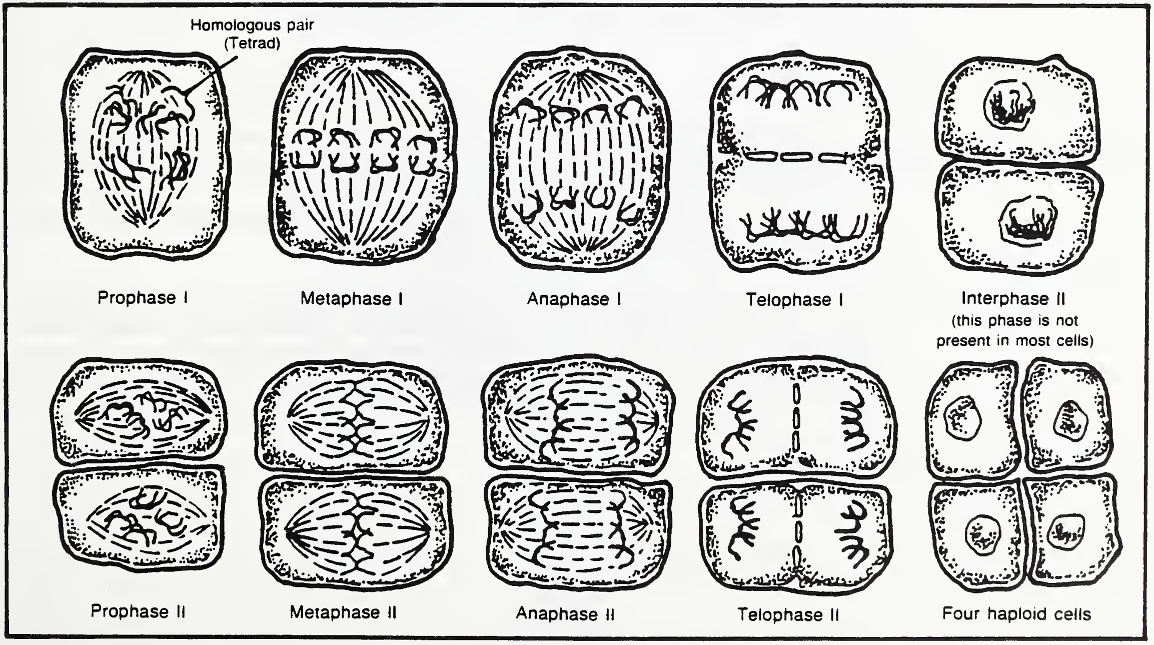


Figure 7: Meiosis. The pairs of homologous chromosomes separate during the first meiotic division. The second meiotic division results in the separation of the chromatids. Four haploid cells are formed.

B. Meiosis II: The Second Cell Division

Review the section of your text dealing with meiosis II (p. 88).

The following table is a summary of the events which take place during meiosis II.

Table 3: Meiosis II: The Second Cell Division

Phase	Major Events
Interphase II	- this stage is absent in most cells - most cells move from Telophase I to Prophase II without a resting stage
Prophase II	- the spindle reforms and the nucleus, if present, disappears
Metaphase II	- the duplicated chromosomes line up along the equator of each cell
Anaphase II	- the kinetochore divides and the sister chromatids separate, each now being called a daughter chromosome - the daughter chromosomes then move to the poles of each cell
Telophase II	- the daughter chromosomes lengthen and the nucleus reforms in each cell - cytokinesis begins and four haploid cells are formed

C. Meiosis in Males

In animals the male reproductive system consists of the **testes** (sperm-producing organs) and the apparatus necessary to convey sperm safely into the female reproductive tract. Sperm production does not begin until the male matures sexually. Changes in hormone secretions bring about sexual maturity and gamete production begins within the testes through a process known as **spermatogenesis**.

Spermatogenesis begins as some of the dividing germinal cells become primary spermatocytes and undergo meiosis. **Each primary spermatocyte that enters meiosis produces four spermatids with the haploid chromosome number**. These spermatids mature within the testes and all along the accessory ducts. At maturity the nonmotile spermatids become motile spermatozoa, ready to fertilize the egg (ovum).

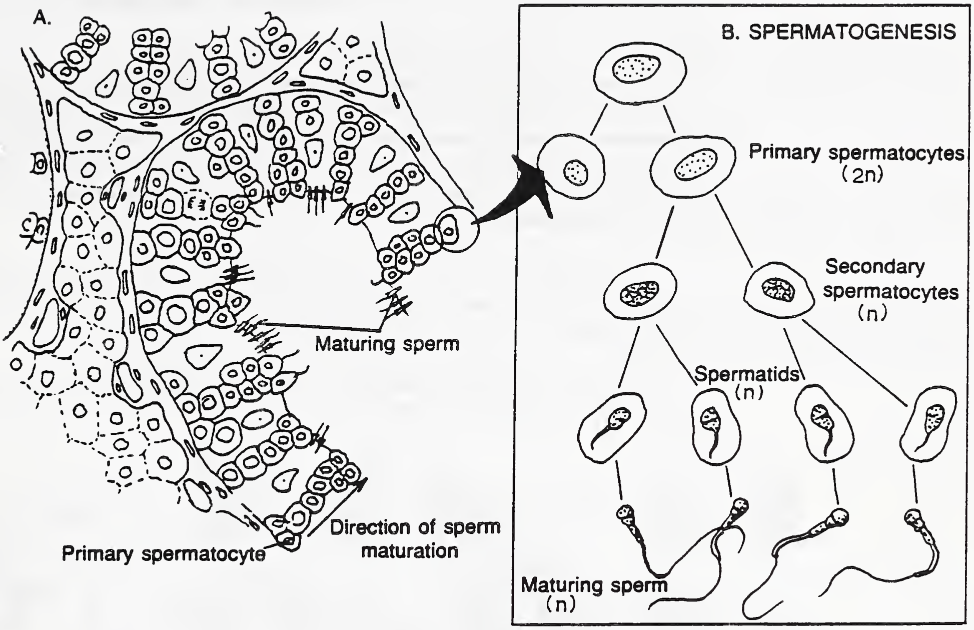


Figure 8: A: A cross section of a portion of the testes showing sperm maturation. B: Spermatogenesis, illustrating the process of meiosis in the male, resulting in the production of four haploid spermatozoa.

D. Meiosis in Females

The female reproductive system consists of the **ovaries** (egg-producing structures) and the apparatus necessary to facilitate the fertilization and in some cases, the development of the ovum (egg).

The two ovaries are the primary sex organs of the female. They are responsible for the production of gametes (eggs or ova). The process by which germinal, diploid cells undergo meiosis to produce haploid gametes is known as **oogenesis.**

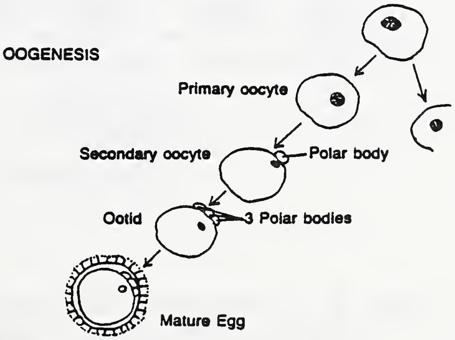


Figure 9: Oogenesis, resulting in one ovum (egg) and three polar bodies.

Note that each primary oocyte which undergoes meiosis gives rise to only **one** mature ovum. This differs from meiosis in males, where each primary spermatocyte gives rise to **four** spermatozoa.

The germ cells which produce the female gametes undergo uneven cell divisions during meiosis. With each cell division, one daughter cell retains the bulk of the cytoplasm. The other daughter cell, containing only nuclear material, is called a *polar body*. Polar bodies cannot function without cytoplasm and thus die within a short period of time. The cell which has retained all of the cytoplasm throughout the meiotic divisions becomes the mature ovum.

This method of cell division during meiosis ensures that at least one ovum will have sufficient internal cytoplasmic reserves to survive the early stages of embryonic development.

The following diagram illustrates both spermatogenesis and oogenesis, allowing a side-by-side comparison of the two processes.

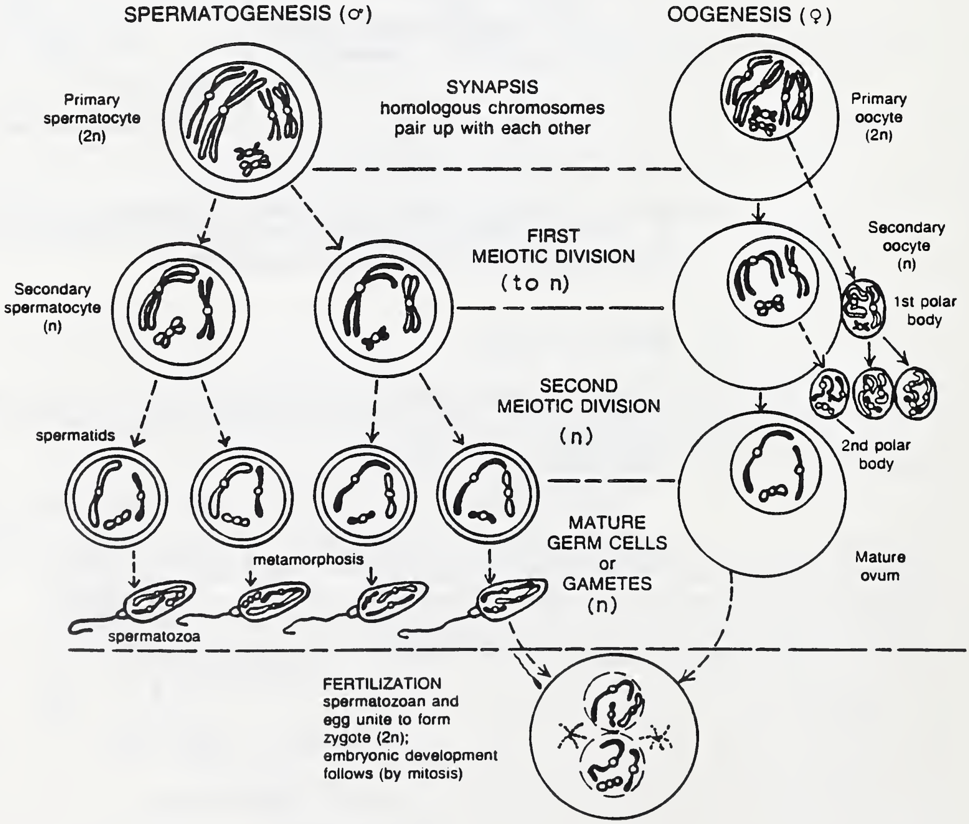

SPERMATOGENESIS (♂)
OOGENESIS (♀)
Primary spermatocyte (2n)
SYNAPSIS homologous chromosomes pair up with each other
Primary oocyte (2n)
Secondary spermatocyte (n)
FIRST MEIOTIC DIVISION (to n)
Secondary oocyte (n)
1st polar body
SECOND MEIOTIC DIVISION (n)
spermatids
2nd polar body
MATURE GERM CELLS or GAMETES (n)
metamorphosis
Mature ovum
spermatozoa
FERTILIZATION spermatozoan and egg unite to form zygote (2n); embryonic development follows (by mitosis)

Figure 10: A comparison of spermatogenesis and oogenesis. Notice that when fertilization occurs the diploid number of chromosomes is restored.

E. Abnormalities in Meiosis

In North America it is estimated that about 1 in 14 children is born with a serious mental or physical defect. This translates into about seven per cent of all live births. Not all these defects can be traced to problems in meiosis but there are certain physical conditions which can be traced to problems in meiotic division.

A mishap during meiosis can mean abnormal chromosome numbers are produced in the gametes. If one of these abnormal gametes is involved in fertilization, the zygote formed will result in an individual with genetic, and possibly physical, defects.

Some birth defects result from the presence of an extra chromosome in the nucleus of every cell in the person's body. Instead of the normal pairing of all chromosomes, one pair has an extra chromosome, making that a threesome. This condition is known as **trisomy**.

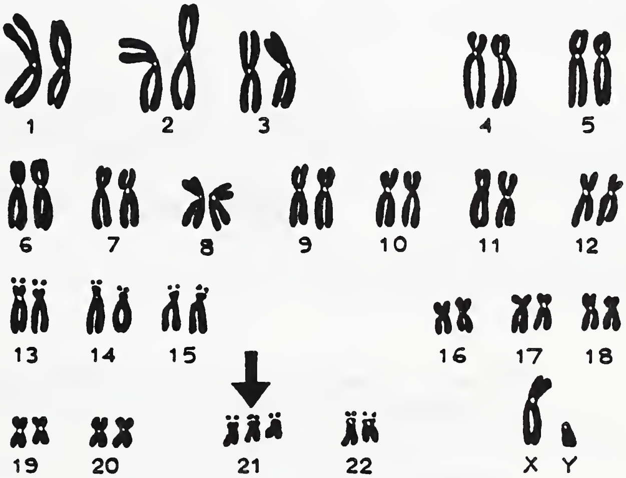


Figure 11: The chromosomes of a person with trisomy. The extra chromosome in pair 21 causes the condition known as Down's syndrome.

The most common cause of trisomy is the failure of a pair of chromosomes to separate during meiosis. This lack of separation is known as **meiotic nondisjunction**. Normally, each protein filament of the spindle pulls one chromosome of a pair away from its partner. Each chromosome is then drawn to opposite sides of the cell. If one filament is broken, both chromosomes will be drawn to the same side of the dividing cell. As a result, one sperm (or ovum) will be formed with an extra chromosome and another gamete will be formed with one less chromosome.

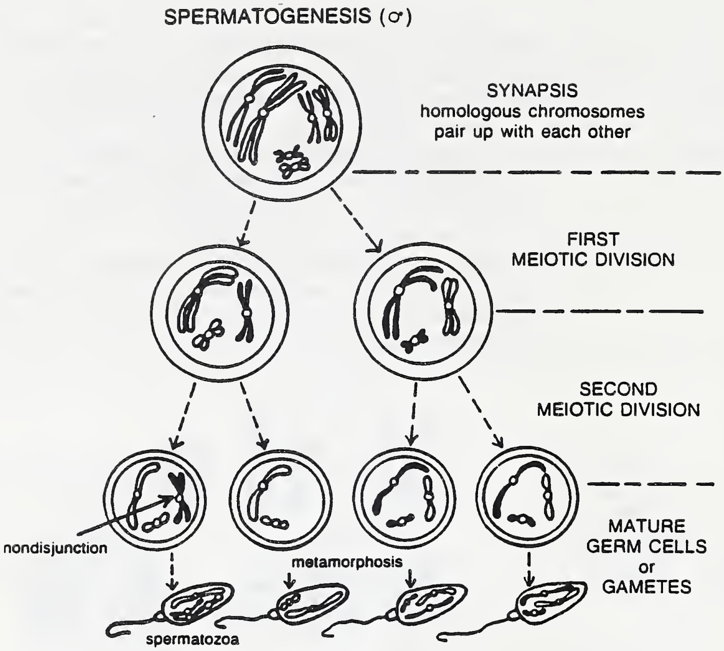


Figure 12: Nondisjunction during spermatogenesis. Notice the difference in chromosome number of the gametes formed.

There are several known human conditions that result from nondisjunction.

Down's Syndrome

When trisomy occurs in chromosome 21, it results in a condition known as Down's syndrome (see Figure 11). The extra chromosome is present in all an individual's cells. This results in severe mental retardation and abnormal physical features, such as an enlarged tongue, short broad hands and generally weak muscles. Historically, this condition was known as mongolism because the victim also possesses almond-shaped eyes.

Down's syndrome occurs in about one 1 in 600 births. This rate varies, however, with the age of the mother. Fewer than one baby in 1,000 is born with Down's syndrome to mothers under 35. For some reason though, about 1 baby in 60 is born with Down's syndrome to mothers over 45.

Other Conditions Resulting from Nondisjunction

READ

Read the section of your text dealing with sex chromosomes and nondisjunction (pp. 133 to 137).

Before discussing two other conditions, Turner's syndrome and Klinefelter's syndrome, the function of the sex chromosomes must be explained.

The sex chromosomes make up one pair of chromosomes present in all sexually reproducing individuals. The components of this pair determine the sex of the individual. Normal females always possess two X chromosomes while normal males must have one X chromosome and one Y chromosome, making up the pair of sex chromosomes. Notice that the individual with Down's syndrome in Figure 11 must be a male, since the sex chromosomes consist of one X and one Y chromosome.

The following conditions both result from nondisjunction of the sex chromosomes.

Turner's Syndrome

Turner's syndrome results from the lack of an X chromosome in the mother's ovum (egg). If this egg is fertilized by a normal X-sperm, the resulting sex chromosomes in the offspring will have the ''XO'' combination. The ''O'' represents the missing X chromosome from the maternal parent.

Individuals with Turner's syndrome do not mature sexually. They are sterile, abnormally short and often have a long neck. One in every 3000 babies is born with Turner's syndrome.

Klinefelter's syndrome

Klinefelter's syndrome results from nondisjunction of the sex chromosomes during sperm formation. If an abnormal sperm, containing both X and Y chromosomes, unites with a normal ovum, the resulting individual will have the XXY combination of sex chromosomes.

The presence of the Y chromosome means that all individuals with Klinefelter's syndrome will be males. This condition is typified by reduced fertility, developed breasts, a feminine-pitched voice, long limbs, knock knees and often, mental retardation. One in every 500 male babies is born with Klinefelter's syndrome.

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

For each of the following questions choose the best answer and write the appropriate letter in the blank provided.

______ 1. The proper number of chromosomes for a cell

(a) is the haploid number.
(b) is the diploid number.
(c) is the same for all species.
(d) varies with each species.

______ 2. Which of the following is **NOT** an acceptable reason for cell division?

(a) To maintain a favorable surface area to volume ratio.
(b) To permit the duplication of the chromosomes.
(c) To accomplish sexual reproduction.
(d) To replace dead or dying cells.

______ 3. Cell division in single-celled organisms could also be referred to as

(a) phagocytosis.
(b) fragmentation.
(c) sexual reproduction.
(d) asexual reproduction.

______ 4. Cells are generally microscopic in size because

(a) they must maintain a proper surface area to volume ratio.
(b) the small size allows for differentiation and diversification of function.
(c) this is the ideal size for the components of multicellular organisms.
(d) they exist in confined spaces which do not allow for further growth.

______ 5. The activities of each cell are controlled by the

(a) RNA within the nucleus.
(b) enzymes within the cell.
(c) DNA within the nucleus.
(d) mitochondria.

______ 6. Cells which possess two complete sets of chromosomes are known as

(a) haploid cells.
(b) diploid cells.
(c) sex cells.
(d) homologous cells.

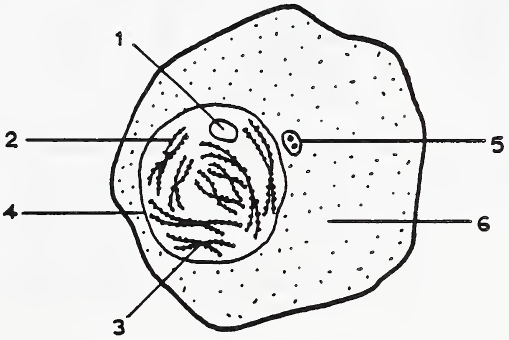
______ 7. The proper number of chromosomes in a human somatic (body) cell is

(a) 23.
(b) 32.
(c) 46.
(d) 64.

______ 8. The portion of the cell cycle during which eukaryotic cells are not in the process of dividing is known as

(a) interphase.
(b) prophase.
(c) mitosis.
(d) cytokinesis.

Use the following diagram to answer questions 9 to 13.



______ 9. Which labelled part represents the nucleus of the cell?

(a) 1
(b) 4
(c) 5
(d) 6

______ 10. The structure labelled number 3 in the diagram is the

(a) centriole.
(b) nucleolus.
(c) mitochondria.
(d) kinetochore.

______ 11. What is the chromosome number of the cell nucleus?

(a) 4
(b) 8
(c) 12
(d) 16

______ 12. If the cell in the diagram is a normal body cell taken from the lining of the mouth, by which one of the following processes will its nucleus divide?

(a) mitosis
(b) meiosis
(c) cytokinesis
(d) reduction division

______ 13. If the cell is gamete-producing, taken from the testes, by what method would its nucleus divide to produce sperm?

(a) mitosis
(b) meiosis
(c) cytokinesis
(d) fragmentation

______ 14. At the end of cell division involving mitosis, the number of chromosomes

(a) in the two daughter cells together is equal to the number in the original cell.
(b) in a daughter cell is double the number in the original cell.
(c) in a daughter cell is equal to the number in the original cell.
(d) in a daughter cell is half the number in the original cell.

______ 15. Which of the following events occurs in meiosis but not in mitosis?

(a) separation of chromatids
(b) pairing up of homologous chromosomes
(c) duplication of chromosomes before division
(d) separation of chromosomes into two cells

______ 16. Mitosis is significant because

(a) the new cell is the same size as the old.
(b) the environment can change the species of individual formed.
(c) the daughter cells have the same genetic makeup as the original cell.
(d) chromosome numbers are reduced by half in each of the daughter cells.

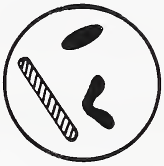
______ 17. Which statement comparing meiosis and mitosis is **TRUE**?

(a) Meiosis involves only one cell division.
(b) Tetrads are formed in both mitosis and meiosis.
(c) Mitosis and meiosis both take place in all cells of the body.
(d) Mitosis results in two diploid daughter cells; meiosis results in four haploid cells.

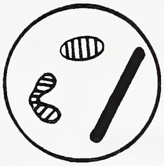
_____ 18. Some cells have many nuclei. This occurs because

(a) cytoplasmic division does not occur.
(b) DNA does not replicate.
(c) chromosome strands do not move to opposite poles.
(d) nuclear membranes are improperly formed.

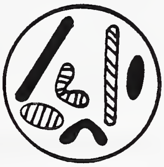
_____ 19. The diagram to the right shows a haploid gamete that resulted from meiosis of a diploid cell. Stripes denote chromosomes inherited from the mother, solid represents chromosomes inherited from the father. The shapes represent different chromosomes. Which diagram represents the diploid cell?



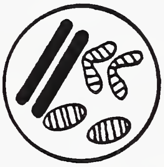
(a)



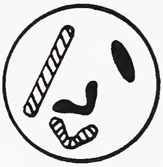
(b)



(c)



(d)



_____ 20. In a normal male human body cell there are two sex chromosomes. These sex chromosomes are given the identifying letters of

(a) XX
(b) WX
(c) XY
(d) YZ

Part Two: Matching and Fill in the Blanks

1. The following is a summary of the events which take place during cell division. These statements are listed in random order. Indicate the proper sequence of events by placing a **1** in the blank in front of the first event, a **2** by the second event, and so on.

_____ the kinetochore divides, the chromosomes separate and move to opposite poles

_____ the nucleolus and nuclear membrane disappear and the spindle forms

_____ cytokinesis begins, leading to the formation of two daughter cells

_____ the chromosomes replicate

_____ the spindle dissolves and the nuclear membrane and nucleolus reform

_____ the chromosomes align along the equator

2. Match the events of meiosis in Column I with the appropriate stage given in Column II by placing the correct letter from Column II in the appropriate blank beside Column I. Do **NOT** use any letter more than once.

Column I

______ cytokinesis begins and four haploid cells are formed

______ the tetrads align along the equator of the cell

______ the kinetochore does not separate; the homologous pairs do separate and move to the poles

______ the kinetochore divides and the daughter chromosomes move to the poles of each cell

______ the homologous chromosomes line up along the equator

______ the chromosomes replicate

______ cytokinesis begins, resulting in two daughter cells

______ homologous chromosomes pair to form a tetrad

Column II

A. Telophase II

B. Metaphase II

C. Interphase

D. Prophase I

E. Anaphase II

F. Prophase II

G. Metaphase I

H. Anaphase I

I. Telophase I

3. The following items require you to make a comparison between mitosis and meiosis. After each statement, a space is provided for you to indicate whether it applies to **mitosis, meiosis** or **both.**

(a) Haploid cells are formed. ______________________

(b) Diploid cells are formed. ______________________

(c) Each chromosome duplicates itself. ______________________

(d) The resulting cells could be sperm cells. ______________________

(e) Chromatids are produced. ______________________

(f) An asexual reproductive process in many unicellular organisms. ______________________

(g) Each daughter cell has the same number and kinds of chromosomes as the parent cell. ______________________

(h) Homologous chromosomes pair up to form a tetrad. ______________________

(i) Prevents an increase in the number of chromosomes from generation to generation. ____________

(j) Spindles form during cell division. ____________

(k) The formation of new epidermis to replace the old tissue. ____________

(l) The nuclear membrane disappears. ____________

4. Complete each of the following statements by filling in the numbered blanks on the right.

(a) The male gametes (sperm) are produced in the __(1)__ . (1) ____________

(b) The process of meiosis in a male is known as __(2)__ . (2) ____________

(c) Each primary spermatocyte that enters meiosis produces __(3)__ haploid gametes. (3) ____________

(d) The egg-producing structures of the female are the __(4)__ . (4) ____________

(e). Each primary oocyte which undergoes oogenesis produces one mature __(5)__ and __(6)__ polar bodies.
(5) ____________
(6) ____________

(f) The process whereby homologous chromosomes pair with each other to form a tetrad is known as __(7)__ . (7) ____________

(g) The presence of an extra chromosome in the nucleus of every cell in a person's body is known as __(8)__ . (8) ____________

(h) The failure of a pair of chromosomes to separate during meiosis is known as meiotic __(9)__ . (9) ____________

(i) The presence of an extra chromosome in pair 21 results in the human condition known as __(10)__ __(10)__ . (two words) (10) __________ __________

(j) Individuals with Klinefelter's syndrome have the __(11)__ combination of sex chromosomes. (11) __________

Part Three: Short Answer

1. How is anaphase in meiosis I different from anaphase in mitosis?

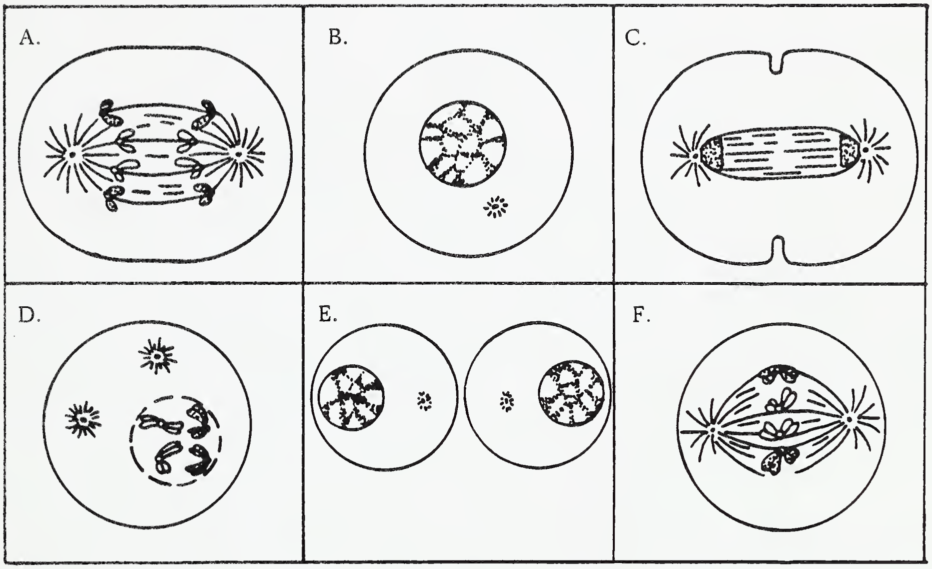
2. Why is it important that a human egg or sperm contain the haploid set of chromosomes rather than just any 23 chromosomes?

3. How does meiosis in a female differ from meiosis in a male?

4. List the composition of the sex chromosomes which determines each of the following:

   (a) A Normal Male = __________
   (b) A Normal Female = __________
   (c) A Female with Turner's Syndrome = __________
   (d) A Male with Klinefelter's Syndrome = __________

5. Identify each of the following phases of cell division by writing the correct phase in the spaces given below the diagrams.



A. ____________________ D. ____________________

B. ____________________ E. ____________________

C. ____________________ F. ____________________

Please submit pages 16 to 23 for correction.

END OF LESSON 8

LESSON RECORD FORM

2230 Biology 20

Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ____________________

Time Spent on Lesson ____________________

(If label is missing or incorrect)

File Number ____________________

Lesson Number ____________

Student's Questions and Comments

Apply Lesson Label Here

Name

Address

Postal Code

Please verify that preprinted label is for correct course and lesson.

FOR SCHOOL USE ONLY

Assigned Teacher: ________

Lesson Grading: ______

Additional Grading E/R/P Code: ______

Mark: __________

Graded by: ________

Assignment Code: _____

Date Lesson Received: ____________

Lesson Recorded _____

Teacher's Comments:

____

Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

PRINCIPLES OF HEREDITY

Introduction

The development of all organisms is shaped by two important factors: *heredity* and *environment*. Heredity is the transmission of traits or characteristics from parents to offspring. You will recall from Lesson 8 that genetic information is passed on to offspring through the processes of meiosis and fertilization. The offspring of sexually reproducing organisms receive half the total number of chromosomes from each parent. These chromosomes contain the genes which code for specific traits or characteristics.

The environment plays an important role in the expression of the inherited characteristics of an individual. The environment includes all the outside forces that act upon an organism, such as food sources, weather, shelter and competition from other organisms.

An individual's height can be used to illustrate the influence of both heredity and environment. Assume that a person possesses the genetic information which codes for an adult height of over 1.8 m. If this person suffered from malnutrition because of a limited amount of food through the growing years, that person would be significantly shorter than 1.8 m at maturity. If the same person had access to a steady, generous food supply, he or she should easily achieve a height of over 1.8 m, barring other negative influences such as disease or accidents.

The science of heredity is a relatively new one, beginning early in the 1900s with the discovery of the works of Gregor Mendel. In this lesson you will review Mendel's experiments, his interpretations and conclusions. Mendel's theories or "laws" now form the basis of modern genetics.

Punnett squares and probability will be dealt with to help you predict the results of one-trait and two-trait crosses. There are a number of new terms in this lesson. A complete understanding of terms such as *genotype, phenotype, homozygous, heterozygous, dominant* and *recessive* should make the study of this lesson an enjoyable experience.

The Life of Gregor Mendel

Gregor Mendel (1822 - 1884) is credited with formulating the principles that have become the basis for modern genetics. These principles include the Law of Dominance, the Law of Segregation and the Law of Independent Assortment.

Gregor Johann Mendel was born July 22, 1822, in Heinzendorf, Austria (now Hyncice, Czechoslovakia). The son of poor peasants, Mendel entered the monastery at Brünn (now Brno, Czechoslovakia) in 1843 to continue his education. He was ordained a priest four years later and spent some time teaching. Showing promise in the field of education, the abbot of the monastery enrolled Mendel in the University of Vienna so he could acquire teacher certification. Mendel studied science and mathematics there for two years. It was this education which gave him the knowledge of statistics and science necessary to perform and interpret future experiments.

Mendel never passed the exam for teacher certification, but nevertheless taught natural history and physics at the Brünn technical high school from 1854 to 1868. It was during this period that Mendel carried out his plant hybridization experiments in the monastery garden.

The results of Mendel's experiments were published in 1866 but they went unnoticed for 32 years. It was not until 1900, sixteen years after Mendel's death, that the value of his work was recognized. Subsequent investigations during the next few decades established Mendel's Laws of Heredity as the basis for the new science of genetics.

Mendel's Experiments

READ

Read the sections of your text dealing with Mendel's first experiments (pp. 101 to 104).

Mendel's experiments in plant breeding began out of an interest in discovering the mechanisms by which characteristics were passed from parents to offspring. In Mendel's day there was no knowledge of chromosomes, genes or DNA. Some scientists thought that characteristics were passed on from generation to generation through something in the blood. Mendel knew that sexually reproducing organisms produced gametes which united to form new individuals. Mendel's experiments were his attempts at discovering the mechanics of heredity.

Mendel began his series of experiments with crosses of pure-breeding parents, each exhibiting a different expression of a given trait. For example, Mendel crossed long-stemmed pea plants with short-stemmed pea plants. The individual plants used for these initial crosses were referred to as the **parents (P or P_1)**, with their offspring being called the **first filial generation (F_1)**. The word filial is derived from the Latin word **filialis**, meaning son or daughter. The offspring of the F_1 generation would be called the **second filial generation (F_2)** and the offspring of the F_2 the **third filial generation (F_3)**.

Because Mendel used parents exhibiting a different expression of a given trait, his initial crosses produced hybrid offspring. Hybrids are individuals which possess a gene pair that contains two different genes, each coding for a different expression of a given trait. When Mendel crossed round-seed pea plants with wrinkled-seed pea plants he found that all of the offspring had round seeds. Similarly, when he crossed green-pod peas with yellow-pod peas, a pattern was established. **Only one expression of the trait remained in the F_1 generation**. Was the other expression of the traits lost forever, or was it simply hidden? To find out Mendel allowed the F_1 pea plants to fertilize themselves and then studied the results. To his surprise the hidden expression of each trait reappeared in the F_2 generation.

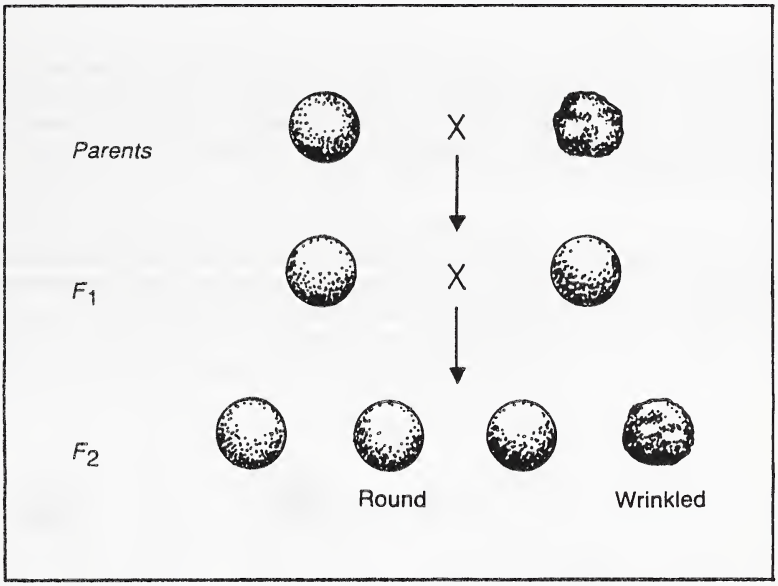


Figure 1: An example of Mendel's first experiments, showing the results of the parental cross and the F_1 cross for the seed shape trait (round vs. wrinkled). Notice that the F_1 generation consists of 100 per cent round-seed pea plants, while the F_2 generation consists of 75 per cent round-seed and 25 per cent wrinkle-seed pea plants.

We now know that traits can be passed from one generation to the next because they are encoded on sections of DNA called genes. All sexually reproducing organisms possess two complete sets of chromosomes, and therefore, two complete sets of genes. When the two genes which code for a certain trait are the same, then the organism is said to be **homozygous** for that trait. If the two genes are different, the organism is said to be **heterozygous** for that trait.

Mendel's experiments involved hundreds of crosses using contrasting expressions of the same trait. He carefully recorded the results of each cross and, by applying simple statistics, was able to develop three principles of heredity which are now the basic laws of genetics.

A. The Law of Dominance

Mendel's parental crosses all involved plants with contrasting expressions for a selected trait (e.g. seed color). These parental plants were also pure-breeding, always giving rise to offspring with the same traits as the parents. These pure-breeding plants would have had to be homozygous for the selected trait.

Mendel found that crosses of two homozygous parents with contrasting expressions of the same trait resulted in an F_1 generation with only one expression of that trait (i.e. they all looked the same). **Refer to the table on p. 104 of your text.**

Mendel referred to the expression of the trait visible in the F_1 generation as **dominant**. The opposite expression of the trait, which was hidden or masked in the F_1 generation, was the **recessive** trait. Round seeds, grey seed coats and long stems are all dominant traits. Wrinkled seeds, white seed coats and short stems are all recessive traits.

The contrasting expressions of a trait are the result of different genes for that trait. The two or more genes which control a trait are called **alleles**. Alleles are genes which occupy the same site on homologous chromosomes and control the same trait. Since sexually reproducing organisms are diploid (two complete sets of chromosomes), two or more alleles must be present for each trait.

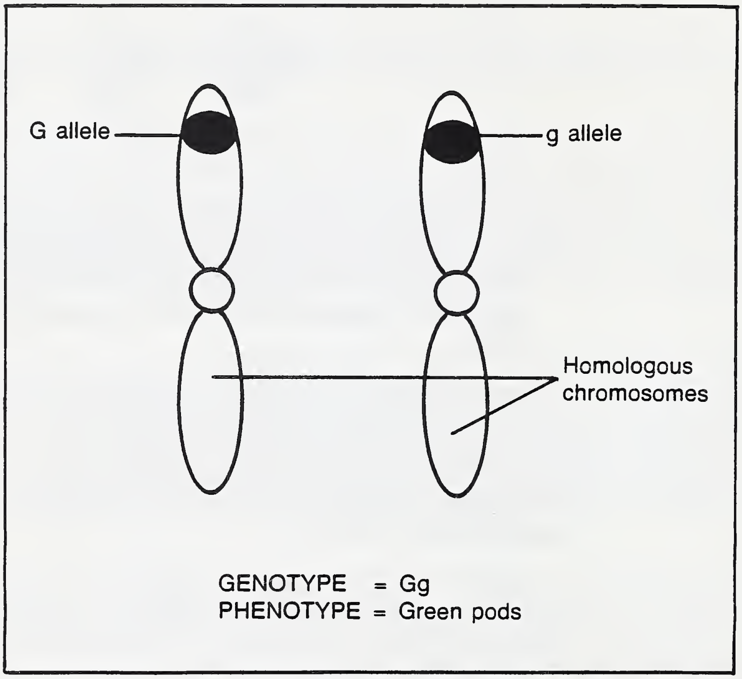


Figure 2: Homologous chromosomes illustrating the genotype of a pea plant which is heterozygous for the trait of pod color. This individual is heterozygous because of the presence of two different alleles.

Alleles are the individual members of a gene pair. The different expressions of a trait can be represented by using letter symbols, with the dominant allele represented by a capital letter and the recessive allele a lowercase letter. Using the trait shown in Figure 2, pod color, you would use a capital letter "**G**" to represent an allele which codes for the dominant trait, green pod color and a lowercase "**g**" to represent the recessive trait, yellow pod color. Notice that the letter chosen to represent the trait is the **first letter** of the dominant expression of the trait. This means that since the green pod color is dominant, the letters "**G**" and "**g**" are used to represent the dominant and recessive alleles.

The combination of alleles an organism has is referred to as its **genotype**. The genotype includes all genes present in the organism. Remember, the genes are those sections of DNA which control the physical and chemical makeup of an organism. The genotype for any particular trait can be expressed by using letter symbols to represent the alleles. The letter symbols "**GG**", "**Gg**" and "**gg**" are examples of the possible genotypes for pod color in pea plants.

The physical trait or characteristic determined by each genotype is called the **phenotype**. Green pods and yellow pods are phenotypes which are determined by the alleles "**G**" and "**g**". Green pods are the physical expression of either the "**GG**" or "**Gg**" genotypes. Yellow pods, however, must have the genotype "**gg**". Notice that different genotypes may result in the same phenotype.

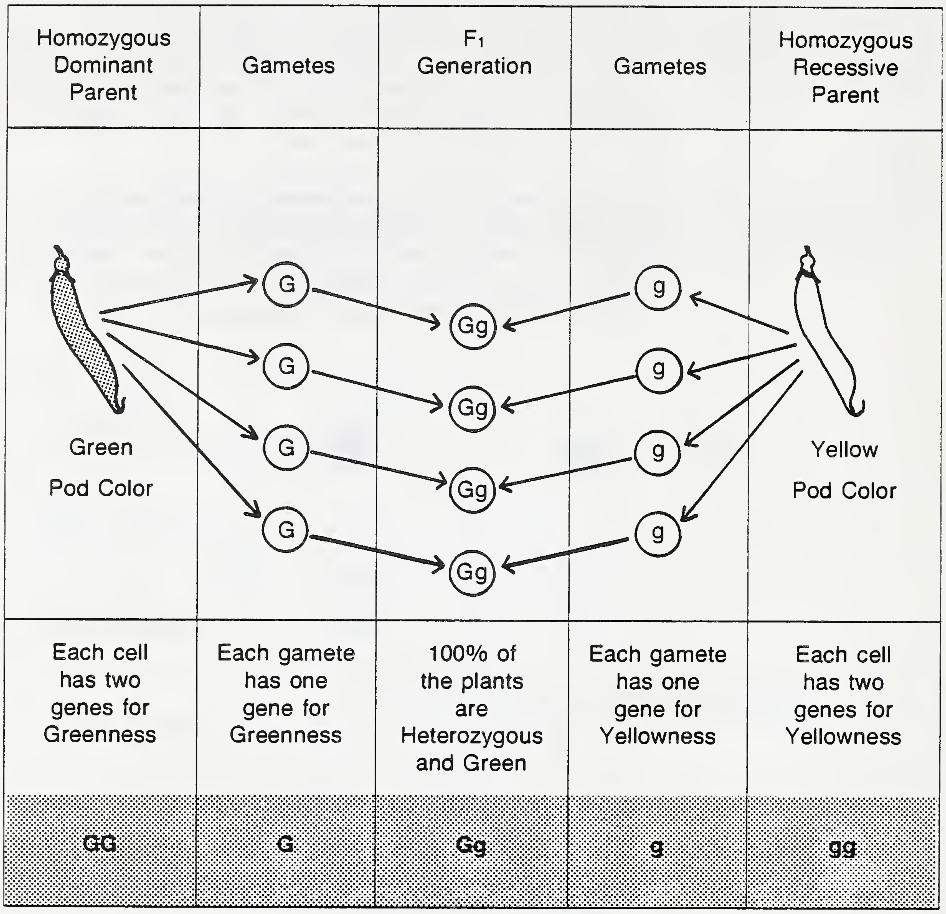
Genotype	**Phenotype**
GG	Green pod color
Gg	Green pod color
gg	Yellow pod color

Figure 3: Genotypes and phenotypes possible for the trait of pod color in garden peas.

When Mendel crossed pea plants with contrasting expressions for seven traits, he found that only the dominant expression of each trait appeared in the F_1 generation. By allowing the F_1 generation to self-pollinate, Mendel found that both the dominant and recessive expressions of each trait were present in the offspring (the F_2 generation).

Refer to the table on p. 104 of your text for the results of Mendel's crosses. These results became the basis of Mendel's **law of dominance**.

The **law of dominance** states that if two parents, each homozygous for contrasting alleles (e.g. **GG** and **gg**) of a trait are crossed, the offspring will inherit one gene from each parent (e.g. **Gg**). Even though two different genes for the trait are inherited by the offspring, only the physical characteristic produced by the dominant gene will appear in the offspring. This gene is therefore called the **dominant** gene. The other gene remains masked or hidden and is called the **recessive** gene. The recessive gene does not influence the development of the physical characteristic produced by the dominant gene for the trait.



Homozygous Dominant Parent	Gametes	F$_1$ Generation	Gametes	Homozygous Recessive Parent
Green Pod Color	G G G G	Gg Gg Gg Gg	g g g g	Yellow Pod Color
Each cell has two genes for Greenness	Each gamete has one gene for Greenness	100% of the plants are Heterozygous and Green	Each gamete has one gene for Yellowness	Each cell has two genes for Yellowness
GG	G	Gg	g	gg

Figure 4: The mechanics of dominance using one of Mendel's experimental crosses.
Note: The shaded area gives the genotype for the cells in each column.

B. The Law of Segregation

When Mendel allowed the F$_1$ generation of pea plants to self-pollinate he was surprised to find that the recessive trait returned in the F$_2$ generation. (Mendel's experiments are summarized on p. 104 of your text.)

To explain the consistent 3:1 ratio of individuals expressing the dominant versus recessive traits in the F$_2$ generation of his experiments, Mendel developed his **law of segregation**. Mendel reasoned the two factors determining the expression of a trait must separate during sexual reproduction and then recombine at random.

We now know that Mendel's "factors" are actually the sections of DNA which code for a trait or characteristic—the genes. Sexual reproduction produces gametes through the process of meiosis. During meiosis a series of divisions occur, reducing the chromosome number of each gamete to 1N. ("read one n") (Meiosis is explained more thoroughly in Lesson 8.)

All of these findings simply confirm Mendel's hypothesis. In modern terms the law of segregation can be explained as follows:

> *Each trait or characteristic is determined by a gene pair. This gene pair separates during meiosis so that each gamete produced receives only one gene for a trait. Gametes then recombine at random during fertilization to restore diploidy (the 2n chromosome number).*

The following is an example of the law of segregation.

A brown-eyed individual having two alleles for brown color will be represented by the letter symbols "BB." "B" refers to the gene that can produce brown eyes. A blue-eyed individual having two alleles for blue eye color will be represented as "bb." The "b" refers to the gene which can produce blue eyes. When segregation takes place in a brown-eyed individual with the genotype "BB," each gamete will contain one "B" gene for the trait eye color. When segregation takes place in a blue-eyed individual with the genotype "bb," each gamete will contain one "b" gene for the trait eye color.

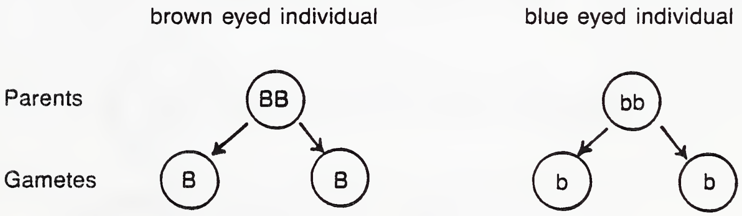


Figure 5: Segregation of genes coding for eye color. Remember, segregation occurs during meiosis.

For the parents shown in Figure 5, all the gametes produced by one parent have the "B" allele and all the gametes produced by the other parent have the "b" allele. Consequently, when there is a union of the two types of gametes from these parents, the offspring will all possess the "Bb" genotype.

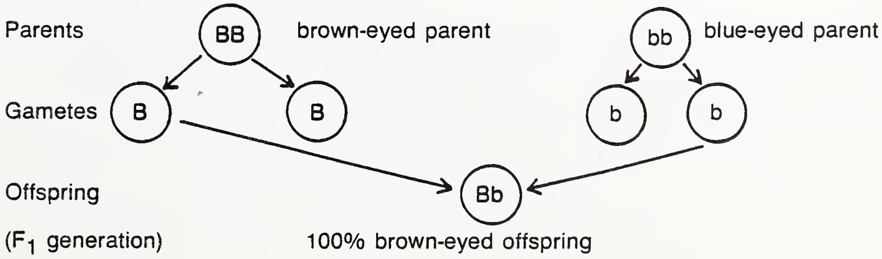


Figure 6: The union of gametes produced by parents which are homozygous for contrasting alleles of a trait.

In this case, the allele for brown eyes is dominant and the allele for blue eyes is recessive. The offspring would possess the brown-eyed phenotype because the allele for brown eyes masks the effects of the allele for blue eyes.

C. The Law of Independent Assortment

Mendel's **law of independent assortment** states that each gene pair undergoing segregation does so independently of all other gene pairs. Mendel thought that each gene was an independent unit of inheritance within the cell. Today we know that genes are the sections of DNA which form the actual units of heredity—the chromosomes.

Mendel's law is correct, as long as the traits being examined are not coded for by genes located on the same chromosome. Genes located on the same chromosome are said to be **linked**. Gene linkage will be dealt with in Lesson 10.

Consider two gene pairs "AaBb." Each pair, "Aa" and "Bb," is composed of contrasting alleles. When segregation occurs for the first pair, the "A" allele will segregate from the "a" allele and will enter gametes containing either the "B" or "b" allele which have also segregated from each other. The gametes containing these segregated genes will have the gene contents "AB" and "Ab" for the two traits. Similary, the "a" allele will segregate from the "A" allele and will enter gametes containing either the "B" or "b" allele to produce gametes with the gene contents "aB" and "ab." Thus, there are four possible allelic combinations when gametes are produced from an individual whose genotype is "AaBb."

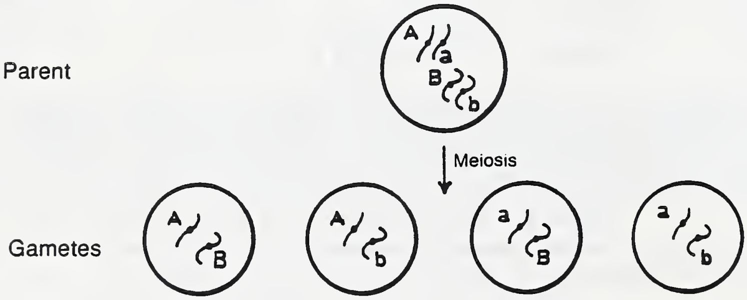


Figure 7: Independent assortment, resulting in the production of gametes containing different combinations of genes after meiosis.

Exercise 1: How Traits are Inherited

Use the lesson notes and assigned readings in your text to complete the following keyed exercise.

1. Complete each of the following statements by filling in the numbered blank on the right.

(a) __(1)__ and __(2)__ are the two major factors in shaping the development of all organisms.

(1) ____________________

(2) ____________________

(b) The works of __(3)__ __(3)__ formed the basis for the new science of genetics.

(3) ____________________

____

(c) The __(4)__ are the sections of DNA which code for a trait or characteristic.

(4) ____________________

(d) Mendel referred to the offspring of the parental crosses as being the __(5)__ __(5)__ generation.

(5) ____________________

____

(e) Individuals possessing a gene pair that contains two different genes, each coding for a different expression of a trait, are called __(6)__.

(6) ____________________

(f) The pure-breeding plants Mendel used in the parental generation were __(7)__ for the trait being studied.

(7) ____________________

(g) The cells of all sexually reproducing organisms possess nuclei which contain two complete sets of __(8)__.

(8) ____________________

(h) Mendel referred to the traits which appeared in the F_1 generation as the __(9)__ traits.

(9) ____________________

(i) Those traits which appear to be hidden or masked in the F_1 generation are known as __(10)__ traits.

(10) ____________________

(j) Two or more genes which control a trait are called __(11)__.

(11) ____________________

(k) The __(12)__ for any particular trait can be expressed by using letter symbols.

(12) ____________________

(l) Mendel found that the hidden or masked traits returned in the __(13)__ __(13)__ generation.

(13) ____________________

____

2. Match the following by writing the letter of the item described in the blank beside each statement. **Do not** use any letter more than once.

______ the trait which is only expressed when the gene pair is homozygous for that trait

______ the actual alleles possessed by an individual

______ the trait which is expressed when the gene pair is heterozygous

______ the genotype in which both alleles of a gene pair are the same

______ the physical expression of a characteristic or trait

______ the genotype in which the alleles of a gene pair are different

A. homozygous
B. genotype
C. heterozygous
D. recessive
E. dominant
F. alleles
G. phenotype

3. The law of segregation involves the separation of paired genes and their random recombination.

(a) When, during sexual reproduction, do gene pairs separate?

____

____

____

(b) When do these genes recombine at random?

____

____

____

4. (a) State the law of independent assortment.

____

____

____

____

____

(b) What structure is now known to "assort independently" during sexual reproduction?

____

____

Check your work with the answers on pp. 24 and 25 of this lesson.

Probability and Punnett Squares

READ

Read the sections of your text dealing with probability and Mendel's experiments (pp. 105-108).

By applying mathematical principles to his experiments Mendel was able to establish various patterns of heredity. Mendel's laws of heredity are based on the **laws of chance**. The laws of chance are mathematical formulas which are used to predict the chance, or **probability**, of something happening.

We all know that when you toss a coin there is an equal probability of tossing either a head or a tail. A coin toss can be considered similar to the segregation of a gene pair, since both are independent events, unaffected by previous results. We can calculate the probability of tossing two tails in a row or the probability of two gametes receiving the same allele, by applying the **product rule**.

The product rule states that the probability of two independent events occurring together is equal to the probability of one event occurring alone **multiplied** by the probability of the other event occurring alone. This means that the probability of tossing two tails in a row would be ½ × ½ or ¼. Similarly, the chances of tossing six heads in a row would be ½ × ½ × ½ × ½ × ½ × ½ or 1/64.

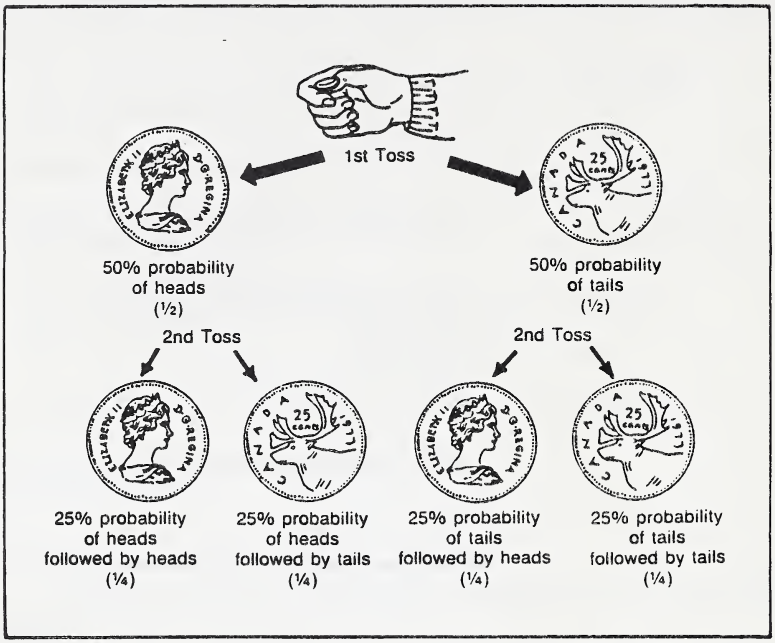
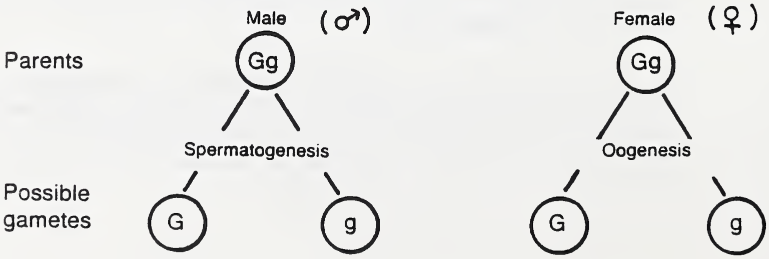

1st Toss
50% probability of heads (½)
50% probability of tails (½)
2nd Toss
2nd Toss
25% probability of heads followed by heads (¼)
25% probability of heads followed by tails (¼)
25% probability of tails followed by heads (¼)
25% probability of tails followed by tails (¼)

Figure 8: Illustration of the product rule using coin tosses. Remember, the probability of tossing heads followed by tails would be ½ × ½ or ¼.

Understanding probability will help you to predict the frequency of a particular gene combination that will result from a cross of two individuals with known genotypes. For instance, the probability of an offspring inheriting a homozygous dominant genotype for the trait of pod color (GG) can be determined if the genotypes of the parents are known. What would be the probability of a homozygous dominant offspring if you were to cross two pea plants which were both heterozygous (Gg) for the trait of pod color?

Remember in the cross, Gg × Gg, two independent events are occurring together. The segregation of alleles during the production of both sperm and eggs are separate events.



You know that only ½ of the sperm and ½ of the eggs will possess the "G" allele. Therefore, the chances of a zygote being produced which is "GG" (homozygous dominant) would be:

½	X	½	=	¼
probability of a "G" sperm		probability of a "G" egg		probability of a "GG" zygote

This does not mean that exactly one out of every four offspring will be homozygous dominant for the trait of pod color. It means that every offspring produced by these heterozygous parents has a one in four chance of being homozygous dominant (GG).

An easy way to visualize all of the possible gene combinations that result from various crosses is to use a **Punnett square**. A Punnett square is a chart with the gametes of one parent written across the top and the gametes of the other parent listed along the left side of the chart (See Figure 9). Each square within the chart represents a possible gene combination which the parents could pass on to the offspring. In other words, each square represents a **possible** zygote.

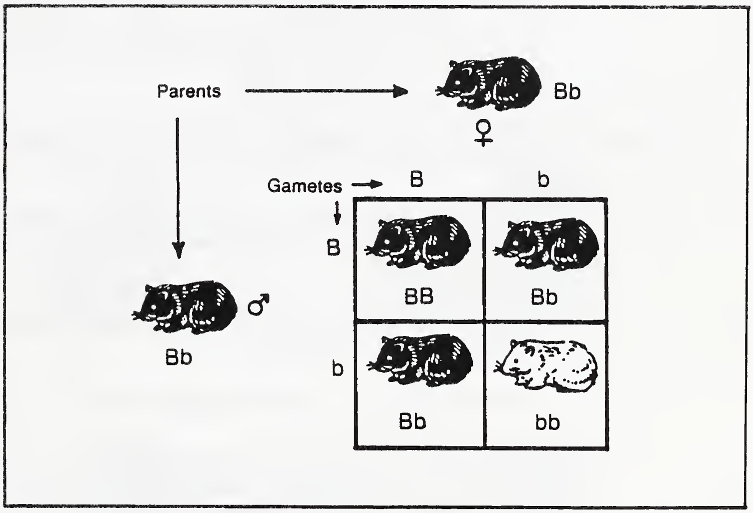


Figure 9: A Punnett square showing the possible genotypes and phenotypes for a cross of two individuals heterozygous for coat color.

The Punnett square in Figure 9 illustrates the possible offspring of a cross between two guinea pigs, each heterozygous for the trait of coat color (Bb × Bb). The letter "B" is used when writing the genotypes for this trait, since the allele for a black coat color is dominant over the allele for white coat color. Most Punnett squares contain only the genotype of each possible zygote. In Figure 9 a diagram of each phenotype is also included.

The inclusion of the phenotypes makes it easier to calculate the possible phenotypic ratios of the offspring. As you can see, the probability of an offspring inheriting a white coat color is one out of four (¼) and the probability of a black offspring is three out of four (¾). Remember, these are simply the probable or expected ratios determined by the laws of chance. It is entirely possible that the two heterozygous parents may produce four offspring, all of which possess the white coat color.

The Inheritance of One Trait

Mendel performed his experiments to study the inheritance of a single trait which was controlled by a single pair of genes. Traits such as eye color, seed coat color and stem length are all controlled by a single pair of genes. To work out a cross for eye color, or any other trait, it is necessary to know the symbols used to express traits and how to apply these symbols.

With Mendel's experiments, you saw some of the ways in which letters are assigned to create genotypes for various traits. The following is a summary of the rules most commonly used in assigning symbols to genes:

1. Use the first letter of the word expressing the phenotype produced by the dominant gene to represent both alleles. For example, for the trait of human eye color, the letter ''b'' is used in both its capitalized and lowercase form because **brown** eye color is the product of the dominant gene.

2. The dominant allele is always capitalized or written in the uppercase form. The dominant allele for brown eye color is written as a capital ''B.''

3. The recessive allele uses the same letter as the dominant allele except that it is written in the lowercase form. The recessive allele for blue eye color is written as a lowercase ''b.''

4. For hybrid (heterozygous) genotypes, the capital letter representing the dominant allele is written first (e.g. ''Bb'').

The following are some examples of the way you would express various traits.

1. In people, the gene controlling brown eyes is dominant and the gene controlling blue eyes is recessive. Consequently, the allele for brown eyes will be ''B'' and the allele for blue eyes will be ''b.''

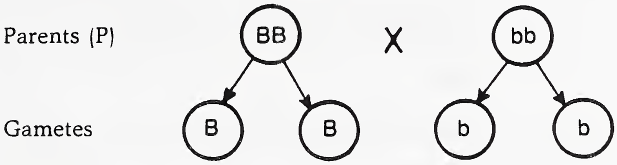
2. In fruit flies, the red-eyed phenotype is the product of a dominant gene and the white-eyed phenotype is the product of recessive genes. Consequently, the allele for red eyes will be written as ''R'' and the allele for white eyes as ''r.''

3. In peas, a green pod is the product of a dominant gene and a yellow pod is the product of recessive alleles for the trait pod color. Consequently, the allele for green pod is ''G'' and the allele for yellow pod is ''g.''

At this point, we should review the symbols used to separate generations of parents and offspring. The parental generation is symbolized by the letter P, the first filial generation of offspring is F_1, the second filial generation is F_2, then F_3 and so on.

The following steps may be used when working out a single-trait cross. These steps will be illustrated by using human eye color as an example of a single trait.

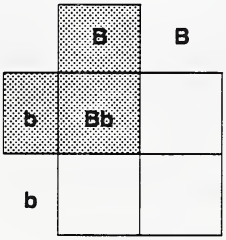
(1) Determine the gametes produced by each parent.

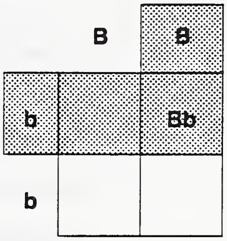


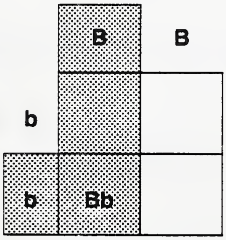
(2) Work out the cross by using a Punnett square. Remember to write the gametes produced by one parent across the top of the square and the gametes produced by the other parent down the left-hand side of the square.

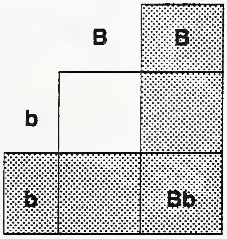
	B	B
b		
b		

(3) Complete the squares by calculating the products of the letters.









(4) The completed Punnett square should be completely filled in as shown.

	B	B
b	Bb	Bb
b	Bb	Bb

The following examples are intended to review the method used for completing one-trait crosses.

(a) The parental generation in this cross includes a homozygous dominant male (BB) and a heterozygous female (Bb) for the trait of human eye color.

Parental Generation (P): BB × Bb

Gametes: B and B × B and b

F$_1$:

	B	B
B		
b		

Initial Punnett Square

	B	B
B	BB	BB
b	Bb	Bb

Completed Punnett Square

Note: The position of the male and female gametes on the Punnett square is arbitrary. Their position will not affect the resulting gene combinations.

(b) The parental generation in this cross includes a heterozygous male (Bb) and a heterozygous female (Bb) for the trait of human eye color. A one-trait cross involving two heterozygous individuals in the parental generation is known as a **monohybrid** cross. Remember that hybrids are individuals with at least one heterozygous trait.

Parental Generation (P): Bb × Bb

Gametes: B and b × B and b

F$_1$:

	B	b
B		
b		

Initial Punnett Square

	B	b
B	BB	Bb
b	Bb	bb

Completed Punnett Square

Note: There are three genotypes produced in this last cross. They are "BB," "Bb" and "bb." Since the trait being studied is eye color, only two phenotypes could possibly be produced. The "BB" and "Bb" genotypes would produce the brown-eyed phenotype and the "bb" genotype would produce the blue-eyed phenotype.

Exercise 2: Probability, Punnett Squares and One-Trait Crosses

1. Using your knowledge of the laws of chance, indicate the probability for each of the following events.

   (a) Rolling a six using one die. ("Dice" is the plural of "die".)

   (b) Tossing a coin which lands heads three times in a row.

   (c) Rolling a five twice in a row using one die.

   (d) A couple has five sons. What are the chances that their next offspring will be male?

2. A box contains three red balls and seven blue balls. If one ball is drawn from the box, what is the probability that it will be red?

3. (a) In sheep, white coat color is dominant to black coat color. If a single pair of genes controls this trait, then what letter would be used to symbolize the genotypes?

____

____

____

(b) Using the information given in 3(a), give the genotypes for each of the following:

(1) a homozygous recessive parent ________

(2) a homozygous dominant parent ________

(3) a hybrid offspring ________

(4) a heterozygous parent ________

(5) a pure black parent ________

4. In rabbits, black coat color is dominant to white coat color. Complete the Punnett square, given a cross between a heterozygous male and a homozygous recessive female (Bb × bb).

Parental Generation (P):

Gametes: ______ and ______ × ______ and ______

F$_1$:

♂

		B	b
♀	b		
	b		

Phenotypic ratio: ____

Genotypic ratio: ____

5. A dominant gene produces wire-haired texture in dogs while the recessive allele produces smooth hair. Complete the following, given a cross between a heterozygous male and a heterozygous female.

Parental Generation (P): ______ × ______

Gametes: ______ and ______ × ______ and ______

F_1:

Phenotypic Ratio: ______________________________

____

Genotypic Ratio: ______________________________

____

Check your work with the answers on pp. 25-27 of this lesson.

The Inheritance of Two Traits

READ

Read the sections of your text which deal with the inheritance of two traits (pp. 108 to 110.)

In addition to his famous one-trait crosses, Mendel also studied the inheritance of two traits in certain varieties of garden peas. Experimental crosses involving two or more traits were performed to confirm Mendel's laws of segregation and independent assortment. Using these laws, Mendel predicted the outcome of a cross between homozygous dominant, round,yellow peas (RRYY) and homozygous recessive, wrinkled, green peas (rryy). As predicted, the F_1 generation consisted entirely of round-yellow peas (RrYy), now heterozygous for each trait. Individuals heterozygous for two traits are known as **dihybrids**. (Refer to Figure 8-7 on page 109 of your text for a diagram of this cross.)

Mendel then let the F_1 generation self-pollinate, resulting in what is now called a **dihybrid cross**. Mendel predicted that the F_2 generation produced by this cross would possess a 9:3:3:1 phenotypic ratio, assuming that the alleles for each trait would assort independently. You now know that to assort independently the alleles for each trait must be found on different chromosomes. Fortunately for Mendel, seed shape and seed color are located on different chromosomes in pea plants, allowing for independent assortment. Figure 8-8 and Table 8-1, on pages 109 and 110 in your text, illustrate Mendel's dihybrid cross along with the probable and resulting phenotypic ratios of the F_2 generation.

The results of a cross involving two independently inherited pairs of genes can be solved using a Punnett square. The same basic steps are used in a two-trait cross as in a one-trait cross, except that there are more genetic combinations. The following is an example of a cross between an individual which is homozygous dominant for two traits and an individual which is homozygous recessive for two traits.

Parents (P): AABB × aabb

Gametes: The four possible gene combinations from the first parent (AB) would be "AB, AB, AB, AB" as each gamete must possess one allele for each trait. Similarly, the four possible gene combinations from the second parent (ab) would be "ab, ab, ab, ab." The arrows on each of the parental genotypes show how the four gene combinations should be arrived at.

Now, draw a Punnett square showing 16 squares, 4 per side. Place the possible gametes of one parent across the top and the gametes of the other parent along the left-hand side. Complete each square by multiplying the letters representing the alleles of each gamete. This will give you the possible combination of genes in the offspring. In the example given, one parent produced all "AB" gametes and the other all "ab" gametes; the product "AB" × "ab" = "AaBb." **Remember to keep the letters of the same trait together.)**

F_1:

	AB	**AB**	**AB**	**AB**
ab	**AaBb**	**AaBb**	**AaBb**	**AaBb**
ab	**AaBb**	**AaBb**	**AaBb**	**AaBb**
ab	**AaBb**	**AaBb**	**AaBb**	**AaBb**
ab	**AaBb**	**AaBb**	**AaBb**	**AaBb**

Note that the genotypes in this particular cross are all the same, "AaBb." Also, there is only one phenotype among the offspring; the one produced by the dominant alleles of both traits.

Here is another example, this time where both parents are heterozygous for both traits.

P: AaBb × AaBb

Gametes: The four possible gene combinations from the first parent whose genotype is "AaBb" would be: "AB, Ab, aB and ab." The other parent also has these four possible gametes "AB, Ab, aB and ab."

F_1:

	AB	Ab	aB	ab
AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
aB	AaBB	AaBb	aaBB	aaBb
ab	AaBb	Aabb	aaBb	aabb

In this cross there are nine possible genotypes and four possible phenotypes in the F_1 generation. The four possible phenotypes and the genotypes for each are shown in the chart below.

The physical appearance of the dominant alleles for both traits is displayed.	The physical appearance of the dominant allele for the 1st trait and the recessive allele for the 2nd trait is displayed.	The physical appearance of the recessive allele for the 1st trait and the dominant allele for the 2nd trait is displayed.	The physical appearance of the recessive allele for both traits is displayed.
AABB, AABb AaBB, AaBb AABb, AaBb AaBB, AaBb AaBb	AAbb Aabb Aabb	aaBB aaBb aaBb	aabb
9	3	3	1

Table 1: The possible phenotypes and genotypes that result from a dihybrid cross.

Note that the phenotypic ratio of the F_1 generation is 9:3:3:1. This means that the probability of an offspring displaying both of the dominant traits is 9 out of 16 or 9/16. Also, the probability of an offspring of the dihybrid cross displaying the dominant 1st trait and a recessive 2nd trait in its phenotype is 3 out of 16 or 3/16, and so on.

Exercise 3: Two-Trait Crosses

1. What is the difference between a two-trait cross and a dihybrid cross?

2. Pea plants that are heterozygous for both stem length (Tt) and pod shape (Rr) are crossed with each other. Indicate the parental genotypes, gametes and F_1 offspring.

P: ____________ × ____________

Gametes of first parent: ______________________________

Gametes of second parent: ______________________________

F_1:

Now, using the information from p. 22 answer the following questions:

(a) What is the probability of having tall, wrinkled offspring?

(b) What is the probability of having offspring that are homozygous for the round-pod shape?

Check your work with the answers on pp. 27 and 28 of this lesson.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, pp. 9-11

1. Complete the statements with the words given below.

(1) **heredity**
(2) **environment**
(3) **Gregor Mendel**
(4) **genes**
(5) **first filial**
(6) **hybrids or heterozygous**
(7) **homozygous**
(8) **chromosomes**
(9) **dominant**
(10) **recessive**
(11) **alleles**
(12) **genotype**
(13) **second filial**

2. Match the following.

D	the trait which is only expressed when the gene pair is homozygous for that trait.
B	the actual alleles possessed by an individual
E	the trait which is expressed when the gene pair is heterozygous
A	the genotype in which both alleles of a gene pair are the same
G	the physical expression of a characteristic or trait
C	the genotype in which the alleles of a gene pair are different

A. homozygous
B. genotype
C. heterozygous
D. recessive
E. dominant
F. alleles
G. phenotype

3. The law of segregation involves the separation of paired genes and their random recombination.

(a) When, during sexual reproduction, do gene pairs separate?

Separation occurs during meiosis, the process by which gametes are formed.

(b) When do these genes recombine at random?

Genes recombine at random when the gametes unite to form a zygote (fertilization).

4. (a) State the law of independent assortment.

   Each gene pair undergoing segregation does so independently of all other gene pairs.

   (b) What structure is now known to assort independently during sexual reproduction?

   The chromosomes are the units of heredity which assort independently.

Exercise 2, pp. 17-19

1. Using your knowledge of the laws of chance, indicate the probability for each of the following events.

   (a) Rolling a six using one die. ("Dice" is the plural of "die".)

   Since a die has six sides, the probability of rolling a six is one out of six (1/6).

   (b) Tossing a coin which lands heads three times in a row.

   ½ × ½ × ½ = 1/8
   The probability of tossing three heads in a row is one out of eight (1/8).

   (c) Rolling a five twice in a row using one die.

   1/6 × 1/6 = 1/36. The probability of rolling two consecutive fives is one out of 36 (1/36).

   (d) A couple has five sons. What are the chances that their next offspring will be male?

   Each birth is an independent event, so the chances of their next offspring being male is ½ or 50 per cent.

2. A box contains three red balls and seven blue balls. If one ball is drawn from the box, what is the probability that it will be red?

   3 → number of favorable outcomes
   10 → total number of outcomes

   The probability of drawing a red ball would be 3 out of 10 (3/10).

3. (a) In sheep, white coat color is dominant to black coat color. If a single pair of genes controls this trait, what letter would be used to symbolize the genotypes?

   A "W" would be used to symbolize coat color in sheep since white is the dominant color.

(b) Using the information given in 3(a), give the genotypes for each of the following:

(1) a homozygous recessive parent **ww**

(2) a homozygous dominant parent **WW**

(3) a hybrid offspring **Ww**

(4) a heterozygous parent **Ww**

(5) a pure black parent **ww**

4. Complete the Punnett square and give the genotypic and phenotypic ratios for the F_1 generation.

Gametes: **B** and **b** × **b** and **b**

F_1:

		♂ B	b
♀	b	Bb	bb
	b	Bb	bb

Phenotypic ratio: **½ black and ½ white**

Genotypic ratio: **½ Bb and ½ bb**

5. A dominant gene produces wire-haired texture in dogs while the recessive allele produces smooth hair. Complete the following, given a cross between a heterozygous male and a heterozygous female.

   Parental Generation (P): **Ww × Ww**

   Gametes: **W** and **w** × **W** and **w**

   F_1:

	W	**w**
W	**WW**	**Ww**
w	**Ww**	**ww**

   Phenotypic Ratio: **¾ wire-haired and ¼ smooth hair**

   Genotypic Ratio: **¼ WW, ½ Ww and ¼ ww**

Exercise 3, pp. 22 and 23

1. What is the difference between a two-trait cross and a dihybrid cross?

   A dihybrid cross is a special type of two-trait cross, involving two heterozygous traits for each individual in the cross. (RrYy × RrYy). Any other cross involving two traits, with any genotype, is a two-trait cross.

2. Pea plants that are heterozygous for both stem length (Tt) and pod shape (Rr) are crossed with each other. Indicate the parental genotypes, gametes and F_1 offspring.

   P: **TtRr × TtRr**

   Gametes of first parent: **TR, Tr, tR, tr**

   Gametes of second parent: **TR, Tr, tR, tr**

   F_1:

	TR	**Tr**	**tR**	**tr**
TR	**TTRR**	**TTRr**	**TtRR**	**TtRr**
Tr	**TTRr**	**TTrr**	**TtRr**	**Ttrr**
tR	**TtRR**	**TtRr**	**ttRR**	**ttRr**
tr	**TtRr**	**Ttrr**	**ttRr**	**ttrr**

(a) What is the probability of having tall, wrinkled offspring?

The probability of having tall, wrinkled offspring is 3 out of 16 or 3/16.

(b) What is the probability of having offspring that are homozygous for the round-pod shape?

The probability of offspring possessing the homozygous dominant genotype for pod shape is 4 out of 16, or 4/16, or 25 per cent).

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

For each of the following questions, choose the best answer and write the appropriate letter in the blank provided.

______ 1. What characteristic of garden peas made them excellent experimental material for Mendel in his genetic studies?

(a) There are usually multiple factors for a trait.
(b) Garden peas are normally self-pollinated.
(c) Crosses between different plants are usually not fertile.
(d) There are only a few features to be studied genetically.

______ 2. The phenotypes of homozygous black guinea pigs and heterozygous black guinea pigs are

(a) BB or Bb
(b) black
(c) Bb or bb
(d) white

______ 3. When an individual of genotype Hh forms gametes, one gamete will receive the H gene and another will receive the h gene. This illustrates Mendel's law of

(a) crossing over.
(b) dominance.
(c) segregation.
(d) independent assortment.

______ 4. If six tosses of a normal coin all result in **heads**, what is the probability that the seventh toss will be a head?

(a) 1/4
(b) 6/7
(c) 1/128
(d) 1/2

______ 5. "A" represents the gene for a dominant trait and "a" its recessive allele. If Aa mates with aa

(a) all offspring will be of the recessive phenotype.
(b) all offspring will be of the dominant phenotype.
(c) 50 per cent of the offspring will be of the recessive phenotype.
(d) 75 per cent of the offspring will be of the dominant phenotype.

Use the following key to answer questions 6 to 9. (Assume B = dominant; b = recessive.)

Key: A. All of the offspring will exhibit the dominant trait.
B. All of the offspring will exhibit the recessive trait.
C. The recessive trait will show up in 50 per cent (1/2) of the offspring.
D. The dominant trait will show up in about 75 per cent (3/4) of the offspring.

What will be the result if

______ 6. Bb × bb?

______ 7. BB × bb?

______ 8. bb × bb?

______ 9. Bb × Bb?

______ 10. In sheep, white coat color (W) is dominant over black coat color (w). If the parental generation consisted of two white sheep, could they produce a black offspring?

(a) Yes, if one of the "grandparents" was a black sheep.
(b) Yes, if one of the parents is heterozygous.
(c) No, one of the parents would have to be black to have black offspring.
(d) Yes, if both of the parents are heterozygous.

______ 11. In determining the color of watermelon fruit, let G = green color and g = striped color. If two Gg plants are crossed, what is the probability of offspring with the homozygous recessive genotype?

(a) 0%
(b) 25%
(c) 50%
(d) 100%

______ 12. In tomato plants let R = round-shaped tomatoes, r = pear-shaped tomatoes, T = tall vines, and t = short vines. A tomato plant with short vines and round fruit has which possible genotype(s)?

(a) RrTt
(b) rrTT
(c) RrTt or RRTT
(d) RRtt or Rrtt

Part Two: Matching and Fill in the Blanks

Use the following information to complete question 1.

In horses, coat color may be black or chestnut (black dominates chestnut) and gait may be trotting or pacing (trotting dominates pacing).

In guinea pigs, coat color maybe black or white (black dominates white) and hair may be short or long (short hair dominates long).

1. Match the genotypes in Column II with the descriptions in Column I. Do not use any letter more than once.

Column I

______ a chestnut, pacing stallion

______ a black, long-haired guinea pig heterozygous for coat color

______ a black, pacing mare, heterozygous for coat color

______ a white, short-haired guinea pig heterozygous for hair length

______ a black, trotting mare, heterozygous for both traits

______ a black, short-haired guinea pig heterozygous for both traits

______ a chestnut, trotting stallion, homozygous for both traits

______ a white, long-haired guinea pig

Column II

A. BbTt

B. bbtt

C. bbTT

D. Bbtt

E. BBTT

F. BbSs

G. bbSs

H. bbss

I. BBss

J. Bbss

2. Use your text (pp. 101 to 110) and the lesson notes to complete each of the following statements by filling in the blank on the right.

(a) ____(1)____ is the branch of statistical arithmetic that tries to predict the results of chance events. (1) ________________

(b) The actual alleles possessed by an individual makes up the individual's ____(2)____. (2) ________________

(c) The cross between an individual with an unknown genotype and a homozygous recessive individual is known as a ____(3)____. (3) ____________

(d) ____(4)____ are genes which occupy the same site on homologous chromosomes and control the same trait. (4) ____________

(e) Separation of a gene pair occurs during ____(5)____. (5) ____________

(f) Genes located on the same chromosome are said to be ____(6)____. (6) ____________

(g) The probability of two independent events occurring together can be calculated using the ____(7)____ ____(7)____. (two words) (7) ____________ ____________

(h) An easy way to visualize all of the possible gene combinations that result from various crosses is to use a ____(8)____ ____(8)____. (two words) (8) ____________ ____________

(i) Individuals which are heterozygous for two traits are known as ____(9)____. (9) ____________

(j) When writing a genotype, the letter for the ____(10)____ trait is always written first. (10) ____________

3. In peas, inflated pods are the product of dominant genes and constricted pods are the product of recessive genes. Long stems are the product of dominant genes and short stems are the product of recessive genes.

(a) What symbols would be used to express a(n)

(i) inflated-pod allele. ______

(ii) constricted-pod allele. ______

(iii) long-stem med. allele. ______

(iv) short-stem med. allele. ______

(b) Indicate the possible genotypes of an individual whose phenotype expresses inflated pods and short stems.

____

(c) Write the genotype for an individual that is hybrid for both pod shape and stem length.

____

Part Three: Short Answer

1. A jar of F_1 fruit flies was counted and the following results obtained:

71 normal-winged, red-eyed
21 normal-winged, sepia-eyed
19 vestigial-winged, red-eyed
5 vestigial-winged, sepia-eyed

(a) What are the (i) dominant traits and (ii) recessive traits?

(i) ______________________________

(ii) ______________________________

(b) What were the parental genotypes?

____

2. In tomatoes, the tall allele (T) dominates the dwarf allele (t) and the allele for purple-stemmed plants (P) dominates the allele for green stems (p).

(a) A tall, purple-stemmed tomato plant (homozygous for both traits) is crossed with a dwarf, green-stemmed tomato plant. Indicate the parental genotypes, gametes and F_1 generation of this cross.

P: __________ × __________

Gametes of first parent: ______________________________

Gametes of second parent: ______________________________

F_1:

(b) The F_1 offspring are crossed with each other. Indicate the parental genotypes, gametes, F_2 generation and the F_2 phenotypic ratio.

P: ____________ × ____________

Gametes of first parent: ________________________

Gametes of second parent: ________________________

F_2:

F_2 phenotypic ratio ______________________.

Part Four: Investigation—Single-Trait Inheritance

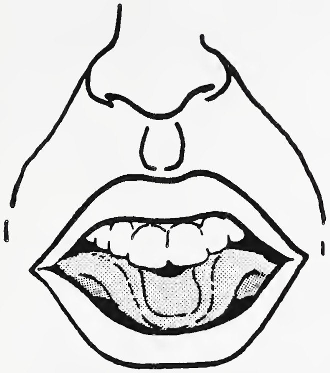
Purpose

1. To study a one-trait hereditary factor, tongue rolling, in a human population sample and to confirm that it is a dominant trait.
2. To determine the nature of the inheritance of tongue rolling in your family and to predict your genetic alleles for this trait.
3. To predict the probabilities of your children for this trait.

Materials and Equipment

1. Twenty or more non-related volunteers.
2. Any available relative.
3. Pencil and paper to record results.

Procedure



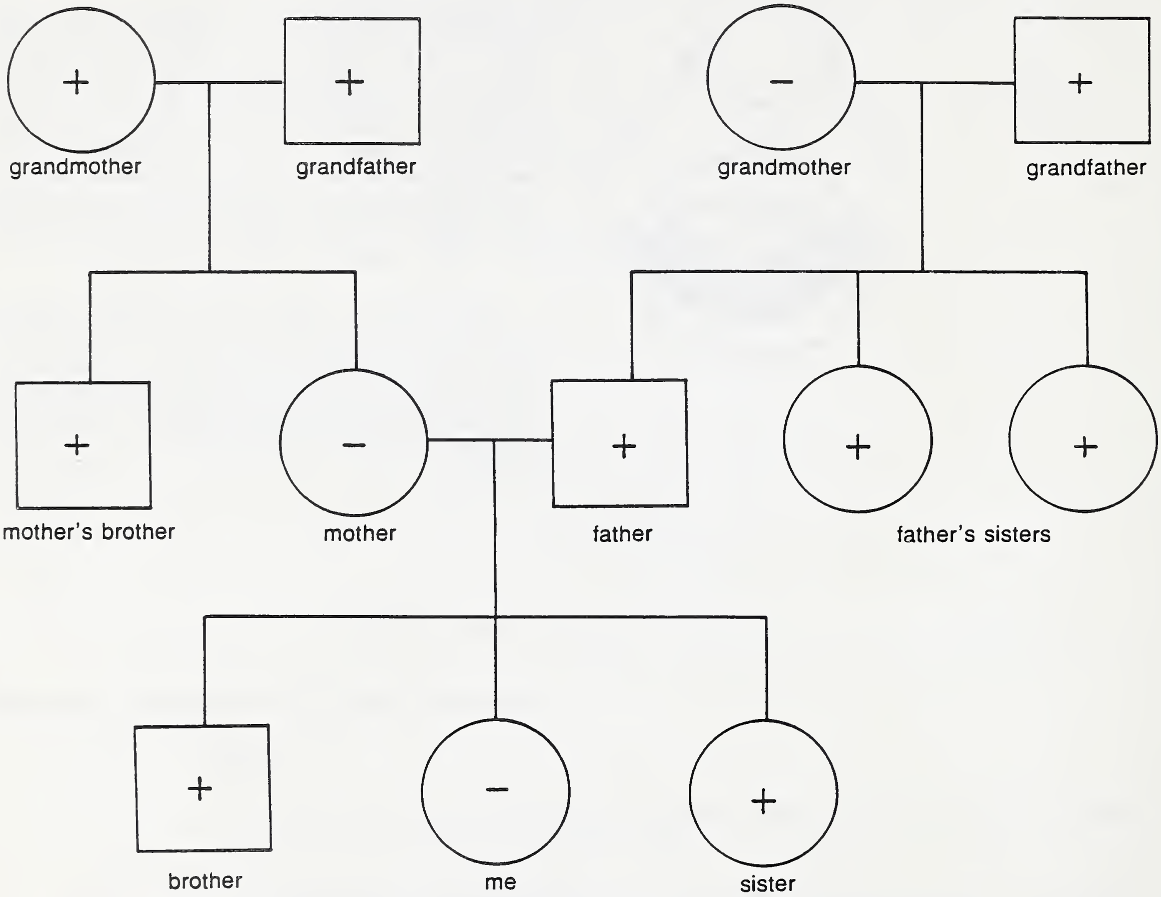
Some people can turn the sides of their tongue so that near the tips the sides almost touch together as illustrated to the left. Other people cannot do this.

Select a minimum of 20 subjects, who are non-relatives for the first part of the experiment (and ask them to try to roll their tongues). Take a count of those who can roll their tongues and those who cannot. Record the numbers of each group on the chart provided on page 37. From this experimental data, indicate what you believe to be the dominant trait and the recessive trait. Give a symbolic letter for each allele. (You should find that tongue rolling is the dominant trait. Use a capital "R" to indicate rollers.)

Next, make a study of all available relatives (brothers, sisters, mother, grandfather, uncle, etc.) to determine their ability to roll their tongues. Record all this information and make an inheritance chart similar to the example on the next page. Place a (+) for anyone who can roll their tongue and a (−) for those who cannot.

Inheritance Chart

This diagram is only an example to help you in preparing your own chart.



○ = female

□ = male

From the family inheritance chart try to predict your genetic alleles for this trait. Then determine what your children will be, if you marry someone who is homozygous dominant, homozygous recessive and heterozygous. Diagram all crosses on page 38.

Results and Conclusions

1. Results of tongue-rolling abilities in your sample.

No. of subjects in the study	No. of rollers	No. of non-rollers	Fraction of rollers	Fraction of non-rollers

2. (a) Dominant Trait ____________________ Allelic Symbol ____________________

   (b) Recessive Trait ____________________ Allelic Symbol ____________________

3. Family Inheritance Chart - Use the chart from page 36 as a guide in preparing your own chart.

4. Personal Results

(a) Are you a roller or a non-roller? ____________________

(b) Probably your genotype is ____________________.

(c) Offspring possibilities

You × homozygous dominant spouse

phenotype(s) of offspring:

____

____

You × homozygous recessive spouse

phenotype(s) of offspring:

____

____

You × heterozygous spouse

phenotype(s) of offspring:

____

____

Questions

1. Could non-roller parents have children that are rollers? Give your reasons.

2. Answer these questions on probability **from the experimental data obtained**.

   (a) What fraction of the sample population are rollers? ____________________

   (b) What fraction of the sample population are non-rollers? ____________________

   (c) What are your alleles for tongue rolling? ____________________

   (d) What are the chances of you marrying someone who carries two recessive alleles for this trait?

   (e) What are the chances of your first child being a non-roller, if your spouse was heterozygous?

   (f) What are the chances of your second child being a roller, if your spouse was heterozygous?

   (g) What would be the chance of you having two boys that are rollers, if your spouse was homozygous dominant?

Submit pp. 29 - 39 of this lesson for correction.

END OF LESSON 9

LESSON RECORD FORM

2230 Biology 20

Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ____________________

Time Spent on Lesson ____________________

(If label is missing
or incorrect)

File Number ____________________

Lesson Number ____________

FOR SCHOOL USE ONLY

Assigned Teacher: ________

Lesson Grading: ________

Additional Grading E/R/P Code: ________

Mark: ________

Graded by: ________

Assignment Code: ______

Date Lesson Received: ____________________

Lesson Recorded ______

Student's Questions and Comments

Apply Lesson Label Here

Name ________

Address ________

____

____

Postal Code ________

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____
Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

PRINCIPLES OF HEREDITY: PART TWO

Introduction

Research into the mechanisms by which traits or characteristics are passed on from one generation to the next did not stop with Mendel's laws of heredity. Science, by its very nature, is a continuous search for new knowledge and ideas to help us explain and understand the world around us. In this lesson, you will look at the discoveries that have been made in the field of genetics following the acceptance and full appreciation of Mendel's work.

Intensive research, using a wide variety of organisms, resulted in the discovery of crosses producing offspring in numbers that did not conform to the predicted Mendelian ratios. Efforts to explain these crosses resulted in discoveries which contributed significantly to our growing knowledge of heredity. In this lesson you will examine the following advancements in the field of genetics: the chromosome theory, sex chromosomes, codominance, incomplete dominance, linkage and crossing over, multiple alleles and mutations.

The Chromosome Theory

READ

Read the section of your text dealing with the chromosome theory (pp. 111 and 112).

Many advancements in the study of cells were made between 1865 and 1900. New staining techniques were developed, giving scientists their first view of the nuclear material within the cell—the chromosomes. Once visible, the actions and behavior of the chromosomes could be observed, thus leading to the discovery of the processes of mitosis and meiosis.

In 1902, Walter S. Sutton and Theodor Boveri each independently developed the chromosome theory. Both men concluded that the units of heredity, the genes, are located on chromosomes. This theory is based on the following observations:

(a) After meiosis, the chromosome number in each gamete is half the original diploid number. This confirms the idea that one gene of each pair is present in each gamete.

(b) The diploid chromosome number is re-established with the union of the sperm and egg. This verifies Mendel's idea that each offspring contains gene pairs made up of one gene from each parent.

(c) Individual chromosomes remain unchanged throughout the processes of mitosis and meiosis, no matter how many cell divisions occur. Thus, genetic information remains unchanged throughout the growth of an organism and from one generation to the next.

(d) Each pair of chromosomes separates independently of any other pair during meiosis. This confirms Mendel's law of independent assortment.

Sutton and Boveri each found that these observations were consistent with Mendel's conclusions. They found, however, that the genes were not individual entities, but rather portions of the chromosomes.

Sex Determination

READ

Read the sections of your text dealing with the fruit fly and sex-linked genes (pp. 112 to 114).

Thomas Hunt Morgan's experimental studies with fruit flies led to his discovery of an unlike pair of chromosomes. Close examination of the chromosomes revealed that three of the four pairs were identical in males and females. In males however, the fourth pair consists of a rod-shaped **X chromosome** and a hooked **Y chromosome**. Female fruit flies possess a fourth pair which consists of two X chromosomes. Since this pair of chromosomes seemed to determine the sex of the organism, Morgan labelled this pair the **sex chromosomes**. The remaining chromosomes are called the **autosomes**. Each set of chromosomes in humans consists of 23 pairs: 22 pairs of autosomes and 1 pair of sex chromosomes.

Although there are other methods by which the sex of an organism is determined, the XX, XY pairings of chromosomes is by far the most common. If sex is considered to be a single trait, then a Mendelian cross can be used to take a closer look at how the sexes are determined.

During egg formation, the diploid cells in the ovary are reduced to the haploid number. Each egg cell will contain an X chromosome. In the male reproductive organs, two kinds of sperm are produced; half containing the X chromosome and the other half containing the Y chromosome. When an egg with an X chromosome unites with a sperm with an X chromosome, the zygote will be XX which means it will develop into a female organism. A union of an egg with the X chromosome and a sperm with the Y chromosome will produce a zygote that is XY; a male offspring. This cross is illustrated in the following diagram.

♀ ♂
P: XX × XY

Symbols
♀ = female
♂ = male

Gametes: X and X from ♀
X and Y from ♂

F$_1$:

♂ \ ♀	**X**	**X**
X	♀ **XX**	♀ **XX**
Y	♂ **XY**	♂ **XY**

Note: The sex ratio of males to females is 1:1.

The sex chromosomes provide some of the best evidence to support the chromosome theory. The presence or absence of a Y chromosome determines the sex of an individual, confirming the idea that the chromosomes do indeed contain information which codes for inheritable traits.

Sex Linkage

In addition to carrying the genes which determine the sexual characteristics of an organism, the sex chromosomes also carry genes which control other individual characteristics. Because of their location on the sex chromosomes, these genes are referred to as **sex-linked** genes.

Sex-linked genes exhibit different hereditary patterns from those expected in Mendelian crosses because some of the genes carried on the X chromosome do not have homologues (partners) on the Y chromosome. Usually the Y chromosome can only duplicate a part of the X chromosome. As a consequence, a male (XY) will have no alleles on the Y chromosome for that part of the X chromosome which the Y chromosome cannot duplicate. Genes on the X chromosome that have no partner on the Y chromosome will be expressed in the phenotype of the male whether they are dominant or recessive.

Because all females have two X chromosomes (XX), all alleles on one of the X chromosomes have partners on the other X chromosomes. If a female inherits a recessive sex-linked gene on one of her X chromosomes, she must also inherit the same allele on the other chromosome if the trait is to appear in her phenotype. If she inherits one recessive sex-linked gene on one X chromosome and a dominant allele on the other X chromosome, the phenotype of the dominant allele instead of the recessive allele will be expressed in her phenotype. The female in this case would be considered a **carrier** of the recessive trait.

Eye color in the fruit fly, a sex-linked characteristic, is discussed in the textbook, pages 112 to 114.

READ

Review this material and then read the section of your text dealing with human sex-linked traits (pp. 137 to 139).

Red-green color blindness is a recessive trait, located on the X chromosome in humans. The X chromosome may possess either the allele for normal color vision (C) or the allele for color blindness (c). The Y chromosome does not possess genes for this trait. Examine the results of two separate crosses: the first involving a homozygous dominant female (X^CX^C) and a colorblind male (X^cY); the second involving a male with normal color vision (X^CY) and a colorblind female (X^cX^c).

Cross 1

P: $X^CX^C \times X^cY$

Gametes: X^C, X^C from ♀

and X^c, Y from ♂

F_1:

	X^C	X^C
X^c	X^CX^c	X^CX^c
Y	X^CY	X^CY

All male and female offspring will have normal color vision.

Cross 2

P: $X^CY \times X^cX^c$

Gametes: X^C, Y from ♂

and X^c, X^c from ♀

F_1:

	X^C	Y
X^c	X^CX^c	X^cY
X^c	X^CX^c	X^cY

The female offspring will have normal color vision but the males will all be colorblind.

These two crosses reinforce the following:

1. Males possess only one X chromosome and it is much more likely that a recessive, sex-linked trait will be expressed in their phenotype.
2. Females can be carriers for recessive, sex-linked traits such as colorblindness and not be colorblind themselves. Males, on the other hand, are colorblind as long as the recessive allele is present in their genotype.

Linkage and Crossing-over

Read the section of your text dealing with linkage and crossing-over (pp. 114 and 115).

When discussing Mendel's law of independent assortment it was stressed that the usual Mendelian ratios could be obtained only by examining traits derived from gene pairs located on different, nonhomologous chromosomes. Since each organism possesses hundreds, or even thousands, of inheritable traits and only a very limited number of chromosomes, it seems obvious that each chromosome must contain many genes. Genes found on the same chromosome tend to be inherited as a unit, rather than being able to assort independently. This phenomenon is known as **linkage**.

The effects of linkage can be summarized as follows:

1. It reduces the number of possible gene combinations available to each gamete (See Figure 1).
2. It reduces the number of possible gametic combinations (zygotes) by preventing independent assortment of the gene pairs (See Figure 2).

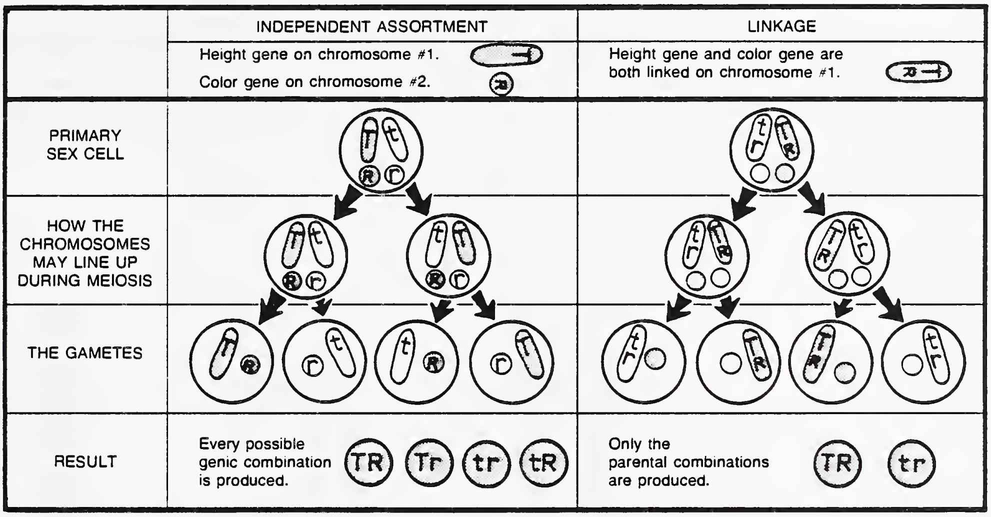

INDEPENDENT ASSORTMENT
Height gene on chromosome #1.
Color gene on chromosome #2.
LINKAGE
Height gene and color gene are both linked on chromosome #1.
PRIMARY SEX CELL
HOW THE CHROMOSOMES MAY LINE UP DURING MEIOSIS
THE GAMETES
RESULT
Every possible genic combination is produced.
TR
Tr
tr
tR
Only the parental combinations are produced.
TR
tr

Figure 1: Comparison of gamete formation where there is no linkage and where linkage exists. Note: linkage results in a decrease in the number of possible gametes.

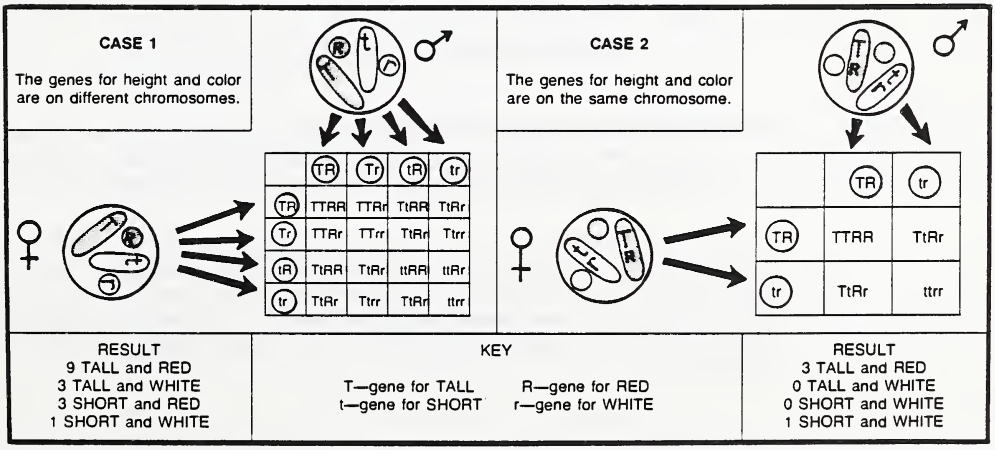


Figure 2: The results of two separate crosses, each involving two plants which are dihybrids. A comparison of the two crosses shows how linkage affects variation.

There is a process which will counteract the reduction in variability due to linkage. Linkages can be broken by **crossing-over**. Crossing-over provides new combinations of linked genes which are called **recombinations**. This process involves the exchange of genetic material between two adjacent chromosomes during meiosis.

Refer to Lesson 8 of this course for a complete description of meiosis.

During prophase I, homologous duplicated chromosomes pair up in a process known as **synapsis** to form a **tetrad** (4 chromatids). Adjacent chromatids in the tetrad often twist around each other and sometimes break where they are twisted. The broken pieces may fuse to the "wrong" chromatid, completing a cross-over of genetic material. If these pieces possess different alleles for the traits coded for on the exchanged sections of DNA, then genetic recombination has occurred.

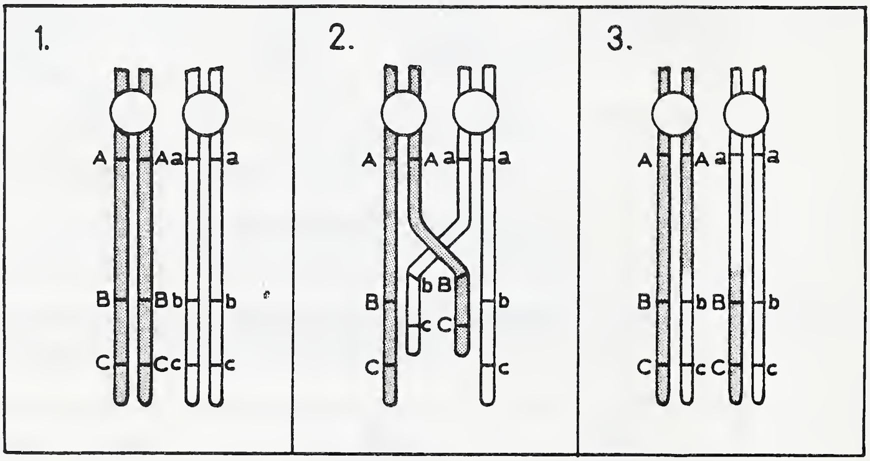


Figure 3: The mechanics of crossing-over: (1) Homologous chromosomes pair up to form a tetrad. (2) Adjacent chromatids twist and break. (3) The broken sections fuse to the "other" chromatid resulting in new combinations of genes.

Notice that crossing-over results in a genetic change in the chromatids involved. Initially the chromatids in Figure 3 contained the following gene combinations: ABC and abc. Crossing-over resulted in a recombination of genes and the production of the Abc and aBC genotypes. Thus, crossing-over has resulted in the presence of the ABC, Abc, aBC and abc genotypes in the tetrad. Clearly, there has been an increase in genetic variability because of the crossing-over process.

Exercise 1: Chromosomes and Linkage

Use the lesson notes and the assigned readings in your text to complete the following keyed exercise.

1. Complete the following statements by filling in the numbered blank on the right.

   (a) __(1)__ and __(2)__ each independently developed the chromosome theory.

   (1) ____________________

   (2) ____________________

   (b) Thomas Hunt Morgan's ideal new organism for genetic research was the __(3)__ __(3)__ (two words).

   (3) ____________________

   ____

   (c) The __(4)__ are those chromosomes which are not involved in the determination of the sex of the organism.

   (4) ____________________

   (d) In fruit flies, the genes for eye color are located on the __(5)__ chromosome.

   (5) ____________________

   (e) A female which carries the recessive allele for a sex-linked trait in her genotype but does not express that trait in her phenotype is called a __(6)__ of that trait.

   (6) ____________________

   (f) Two sex-linked traits which occur in humans are __(7)__ and __(8)__.

   (7) ____________________

   (8) ____________________

   (g) The exchange of material between two adjacent chromatids is called __(9)__.

   (9) ____________________

   (h) __(10)__ reduces the number of possible gametic combinations by preventing independent assortment.

   (10) ____________________

2. In a certain animal, coat color is a sex-linked characteristic. Also, the gene for black coat color (B) is dominant to the gene for orange coat color. Determine the probable genotypic and phenotypic ratios for the offspring of a heterozygous female and a black male.

   Parents (P): $X^BX^b \times X^BY$

   Gametes: ______ and ______ × ______ and ______

   F_1:

Genotypic Ratio: ______________________________

____

Phenotypic Ratio: ______________________________

____

3. Explain why blue eyes and blond hair or brown eyes and brown hair are commonly inherited together.

____

____

____

Check your work with the answers on p. 15 of this lesson.

Incomplete Dominance

READ

Read the section of your text dealing with incomplete dominance (pp. 115 and 116).

In his experiments, Mendel was able to identify a dominant and recessive version of each trait being studied. Since one allele in each gene pair was clearly dominant, individuals possessing heterozygous genotypes had the same phenotype as homozygous dominant individuals. Mendel used this fact as a basis for his law of dominance.

Continued research, using a wide variety of organisms, has led to the discovery of quite a large number of exceptions to Mendel's law of dominance. Japanese four o'clocks, snapdragons and Andalusian fowl are just a few of the organisms which possess certain traits where the heterozygote is quite different from both the homozygous dominant and the homozygous recessive individuals.

When neither allele present in a gene pair is dominant over the other, the resulting phenotype of a heterozygous individual is often an intermediate or blended version of the two alleles. For example, a cross involving red four o'clocks (RR) and white four o'clocks (WW) results in an F_1 generation made up entirely of pink four o'clocks (RW). This is an example of **incomplete dominance** between the alleles governing flower color in the Japanese four o'clock. The diagram on the next page illustrates incomplete dominance in Andalusian fowl.

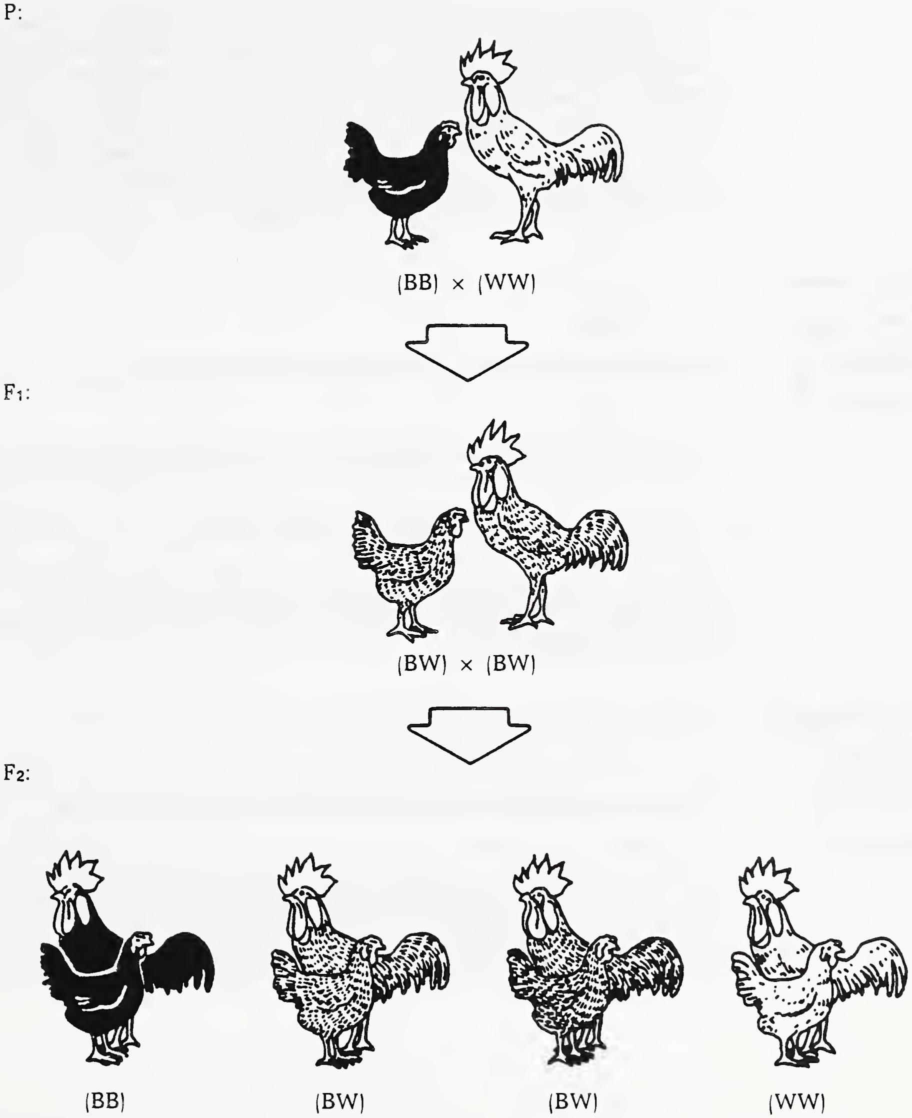


Figure 4: Incomplete dominance in Andalusian fowl. The parental cross of a white-splashed fowl (WW) and a black Andalusian fowl (BB) results in an F_1 generation consisting entirely of blue fowl (BW). Mating two of the blue fowl results in an F_2 generation with the following phenotypic ratio: 1 white-splashed: 2 blue: 1 black.

Notice that those traits exhibiting incomplete dominance in your text are written using one letter in its upper and lowercase forms (p. 116). In this lesson traits exhibiting incomplete dominance are given genotypes in which **the alleles are written using two different capital letters**. Each capital letter chosen represents the phenotype of the homozygous individual. Black Andalusian fowl are given the "BB" genotype while white-splashed fowl are represented by the "WW" genotype. The use of two separate capital letters in the genotype of an individual should immediately convey the idea that this is a trait which exhibits incomplete dominance. The system used by the text does not do that.

Codominance

READ

Read the section of your text dealing with codominance (p. 116).

Codominance is a gene relationship whereby both alleles of a gene pair are fully expressed in a heterozygote. Your text uses coat color in shorthorn cattle to illustrate this phenomenon.

Codominance differs from incomplete dominance in that two traits are present in the phenotype of an organism at the same time and neither appears to be dominant. Roan shorthorn cattle possess a coat which contains a mixture of red hairs and white hairs. If this was a case of incomplete dominance then each hair would be a blended, intermediate color between red and white.

Multiple Alleles

READ

Read the section of the text dealing with multiple alleles (pp. 117 and 118).

When more than two alleles exist for a given trait they are called **multiple alleles**. Human blood groups are an excellent example of both multiple alleles and codominance. In man, the inheritance of blood groups is determined by three alleles: I^a, I^b and i. Combinations of these alleles result in six different genotypes and four phenotypes for the blood grouping trait (See Figure 5).

GENOTYPE	BLOOD GROUP (PHENOTYPE)
I^aI^a I^ai	**A**
I^bI^b I^bi	**B**
I^aI^b	**AB**
$i\ i$	**O**

Figure 5: Possible genotypes and phenotypes of human blood type.

As shown in Figure 5, the i-allele is recessive when combined with either the I^a or I^b alleles in a gene pair. Genes I^a and I^b however, are codominant, with each allele expressing its phenotype in the I^aI^b combination as if the other gene were not present.

Remember that no matter how many alleles may exist for a certain trait, each individual organism can possess only two alleles. Each gene pair consists of one allele from the mother and one from the father. Thus, it is impossible for an individual to possess all three alleles for human blood type (the I^aI^bi genotype cannot exist).

Multiple alleles are thought to be the result of genetic changes in the "original" gene pair. Changes in the physical structure of a gene may result in the production of new phenotypes. If a new phenotype is advantageous to an organism, or has no adverse effect on its existence, the new gene will probably remain in the genotype. Thus, with more than two alleles now available for a specific trait, the term "multiple alleles" can be used to describe the situation.

Mutations

Sudden genetic changes, such as those which produce multiple alleles are known as **mutations** and the organisms in which they occur are called **mutants**.

Genes replicate and chromosomes segregate during mitosis and meiosis in a very regular way. In rare instances however, genetic changes occur, bringing about mutations. Mutations are beneficial to a species, in so far as they increase the phenotypic diversity within the species.

The individual mutant is usually adversely affected by the genetic changes which occur, as most visible mutations are usually harmful and often lethal. With enough mutations however, a few beneficial ones may develop and become prevalent in a species. Beneficial mutations aid the species by making it more suitably adapted to the environment. Thus, mutations are seen as beneficial at the species level even though they are usually harmful to the individual mutants.

Some mutations produce visible changes in the structure of the chromosome. These are known as **chromosomal mutations**. For instance, a small segment of a chromosome may be missing, or represented two or three times; a segment of one chromosome may be translocated to a new position on a new chromosome; or a part of a chromosome may be turned end for end and then attached to its usual chromosome. These mutations usually have a drastic effect on an organism since each segment of a chromosome possesses a large number of genes.

In other instances, no visible changes in chromosome structure occur; rather, a small change occurs on the molecular level where the chemical structure of the nucleoprotein composing the gene is changed. This type of genetic change is known as a **point mutation** or **gene mutation**. Gene mutations are the most common type of mutation, being responsible for conditions such as albinism and sickle-cell anemia.

A mutation occurring in the body cells of plants or animals will appear in all of the tissues arising from the original mutated cell. Such a mutation is known as a **somatic mutation**. These mutations will not appear in new offspring unless the adult reproduces vegetatively. Vegetative reproduction is a type of asexual reproduction which occurs during a plant's growing stage. New strawberry plants are often produced asexually, when existing plants send out runners from which many new plants will grow. Somatic mutations then, are of little importance in our discussion of heredity.

Mutations that occur in reproductive cells and are transmitted to new offspring are called **germ mutations**. Germ mutations are of great importance since they alter the genetic makeup of new individuals. These changes may be beneficial to the new individuals by providing characteristics with some survival value. Germ mutations, however, usually decrease the chances of survival for new individuals. Pelicans that are born without wings are not able to survive. Mutant genes that kill the individuals inheriting them are known as **lethal genes**.

Causes of Mutation

Substances and conditions that cause mutations are known as **mutagens**. The first substance identified as a mutagen was the poisonous nitrogen-mustard gas — a chemical weapon used in World War I. Since this first discovery the list of mutagens has grown considerably to include a wide variety of things. High-energy radiation, such as X-rays, and high temperatures are often used by scientists to increase the rate of mutations in experimental animals and plants. Other known mutagens include certain viruses, certain food additives, various industrial chemicals such as formaldehyde, smoke, smog and tar.

Exposure to mutagens increases the possibility that cells within an organism will mutate. Remember, future offspring are only affected by germ mutations in the parent. Somatic mutations in an organism may lead to the development of cancer within the individual, but future generations will not inherit this.

Mutagens have always been present in the environment, but industrialization has increased their number and variety.

Exercise 2: Mendelism Modified

1. When expressing multiple alleles, the allele for the dominant trait is capitalized, while the allele for the recessive trait is expressed in the lower case form. All the alleles for intermediate traits are assigned a lower case letter with a suitable superscript.

   Coat color in rabbits is a trait governed by multiple alleles. The normal or wild-type allele is dominant over the others and is representd by a capital C. The recessive allele "c" codes for the albino, which lacks pigment of any kind. The two intermediate alleles are "c^{ch}" (chinchilla) and "c^{h}" (Himalayan). The order of dominance for these alleles is $C > c^{ch} > c^{h} > c$. The following table shows the interrelationship between genotypes and phenotypes.

Phenotypes	Genotypes
Wild-type	CC, Cc^{ch}, Cc^{h}, Cc
Chinchilla	$c^{ch}c^{ch}$, $c^{ch}c^{h}$, $c^{ch}c$
Himalayan	$c^{h}c^{h}$, $c^{h}c$
Albino	cc

Note: The four varieties of coat color in rabbits are illustrated on page 117 of your text.

(a) Use the above information to help you determine the genotypic and phenotypic ratios of the F_1 generation, given the following parents:

Parents (P): $Cc^{h} \times c^{ch}c$

Gametes: ______ and ______ × ______ and ______

F_1:

Genotypic Ratio: ______________________________

____

Phenotypic Ratio: ______________________________

____

(b) What were the phenotypes of the parents in the above cross?

____

____

2. Complete the following statements by filling in the numbered blanks on the right.

(a) __(1)__ is a gene relationship whereby both alleles of a gene pair are fully expressed in a heterozygote.

(1) ____________________

(b) When more than two alleles exist for a given trait they are called __(2)__ __(2)__. (two words)

(2) ____________________

(c) An individual will possess Type B blood if he or she has either the __(3)__ or __(4)__ genotype for blood group.

(3) ____________________

(4) ____________________

(d) Sudden changes in either chromosomal or gene structure are known as __(5)__.

(5) ____________________

(e) An Andalusian fowl which possesses the "BW" genotype for plummage coloration would be __(6)__ in color.

(6) ____________________

(f) Substances or conditions that cause mutations are known as __(7)__.

(7) ____________________

(8) ____________________

(g) Mutations are seen as beneficial to the __(8)__ but harmful to the __(9)__.

(9) ____________________

(h) Sickle-cell anemia and albinism are the result of __(10)__ mutations.

(10) ____________________

Check your work with the answers on p. 16 of this lesson.

ANSWERS TO THE KEYED EXERCISES

Exercise 1, pp. 7 and 8

1. Complete the statements with the words given below.

(1) **Sutton**
(2) **Boveri**
(3) **fruit fly**
(4) **autosomes**
(5) **X**
(6) **carrier**
(7) **hemophilia**
(8) **color blindness**
(9) **crossing-over**
(10) **linkage**

2. Determine the probable genotypic and phenotypic ratios for the offspring of a heterozygous female and a black male.

Parents (P): $X^BX^b \times X^BY$

Gametes: **X^B** and **X^b** × **X^B** and **Y**

F_1:

	X^B	**Y**
X^B	**X^BX^B**	**X^BY**
X^b	**X^BX^b**	**X^bY**

Genotypic Ratio: **¼ X^BX^B, ¼ X^BY,**

¼ X^BX^b, ¼ X^bY

Phenotypic Ratio: **½ black females: ¼ black males: ¼ orange males**

3. Explain why blue eyes and blond hair or brown eyes and brown hair are commonly inherited together.

The alleles governing these traits are probably linked.

Exercise 2, pp. 14-15.

1. (a) Determine the genotypic and phenotypic ratios of the F_1 generation, given the following cross:

Parents (P): Cc^h × $c^{ch}c$

Gametes: **C** and **c^h** × **c^{ch}** and **c**

F_1:

	c^{ch}	c
C	Cc^{ch}	Cc
c^h	$c^{ch}c^h$	c^hc

Genotypic Ratio: **¼ Cc^{ch} : ¼ Cc : ¼ $c^{ch}c^h$: ¼ c^hc**

Phenotypic Ratio: **½ wild-type : ¼ chinchilla : ¼ Himalayan**

(b) What were the phenotypes of the parents in the above cross?

The two phenotypes expressed in the parental cross were the wild-type and chinchilla coat color.

2. Complete the statements with the words given below:

(1) **Codominance**
(2) **multiple alleles**
(3) **I^bI^b**
(4) **I^bi**
(5) **mutations**
(6) **blue**
(7) **mutagens**
(8) **species**
(9) **individuals**
(10) **point or gene**

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

For each of the following questions, choose the best answer and write the appropriate letter in the blank provided.

_____ 1. Thomas Hunt Morgan's experiments evolved around an ideal new organism for genetic research:

(a) fruit flies.
(b) bread mold.
(c) pea plants.
(d) enzymes.

_____ 2. Morgan found that the chromosomes of one pair in his experimental organism were not alike. He called this pair the

(a) autosomes.
(b) mutagens.
(c) sex chromosomes.
(d) recessive alleles.

_____ 3. Hemophilia is a sex-linked trait. A female that possesses the X^HX^h genotype

(a) is called a carrier.
(b) has a father with hemophilia.
(c) is called a hemophiliac.
(d) will show the recessive trait.

_____ 4. Genetic defects on the X chromosome can be transmitted to a male by

(a) only his mother.
(b) only his father.
(c) either his mother or father.
(d) mutation only.

_____ 5. A man with type AB blood marries a woman with type A blood. What blood type would **not** be found in any of their children?

(a) type A
(b) type B
(c) type AB
(d) type O

______ 6. A certain breed of cattle in England produces good meat when a particular gene is heterozygous. This same gene is lethal when it is homozygous recessive. To produce the best meat possible without losing any cattle, a British rancher should

(a) establish a herd with all homozygous dominant cattle.
(b) breed the homozygous recessives with homozygous dominant cattle.
(c) breed heterozygous cattle with homozygous dominant cattle.
(d) breed heterozygous cattle with one another.

______ 7. In fruit flies, normal body color (N) is dominant over ebony body color (n). Which of the following are likely to be the genotypes of the parents if all of the F_1 generation have the normal body color?

(a) Nn × Nn
(b) nn × Nn
(c) nn × nn
(d) NN × Nn

______ 8. Which of the following groups are known to cause mutations in human offspring?

(a) atomic radiation, sound waves, radio waves
(b) atomic radiation, certain drugs, X-rays
(c) sound waves, certain drugs, sunlight
(d) certain drugs, X-rays, sunlight

The next two items demonstrate how multiple alleles can be used to solve difficult problems. The following chart is a quick reference of blood types and their possible genotypes.

Blood Type	**Genotype**
A	I^aI^a, or I^ai
B	I^bI^b, or I^bi
AB	I^aI^b
O	ii

The maternity ward of a hospital recently had a mix-up involving three newborn infants. The identification tags were accidentally removed and the three babies were very similar in appearance. The blood types of the possible parents and babies are shown below:

Individuals	**Blood Types**
Parents I	B and B
Parents II	A and AB
Parents III	AB and O
Baby 1	A
Baby 2	O
Baby 3	AB

_____ 9. Who were the possible parents of Baby 1?

(a) I only
(b) III only
(c) I and II
(d) II and III

_____ 10. Who were the possible parents of Baby 2?

(a) I only
(b) II only
(c) III only
(d) I and III

______ 11. A **reduction** in the number of possible gene combinations available to each gamete is the result of

(a) crossing-over.
(b) linkage.
(c) incomplete dominance.
(d) codominance.

______ 12. An **increase** in the number of possible gene combinations available to each gamete is often the result of

(a) crossing-over.
(b) linkage.
(c) incomplete dominance.
(d) codominance.

The next 2 items are based on the following information on snapdragons.

Tallness (T) is dominant to dwarfness (t), while flower color demonstrates incomplete dominance. A cross between a red flower (RR) and a white flower (WW) produces pink-flowered offspring (RW).

______ 13. A dwarf red snapdragon is crossed with a plant homozygous for tallness and white flowers. The genotype and phenotype of the F_1 individuals are

(a) ttRW - dwarf and pink.
(b) ttWW - dwarf and white.
(c) TtRR - tall and red.
(d) TtRW - tall and pink.

______ 14. If two plants of the genotypes ttRW × TtRR were crossed and no mutations occurred, what would be the probability of producing a dwarf white plant?

(a) 0%
(b) 25%
(c) 50%
(d) 100%

______ 15. Color blindness is a sex-linked trait. If a color blind man marries a woman heterozygous for the trait, what are their chances of having color blind children?

(a) All the children will be color blind.
(b) All the children (male or female) have a 50% chance of being color blind.
(c) 50% chance of a color blind boy; 0% chance of a color blind girl.
(d) 50% chance of a color blind girl; 0% chance of a color blind boy.

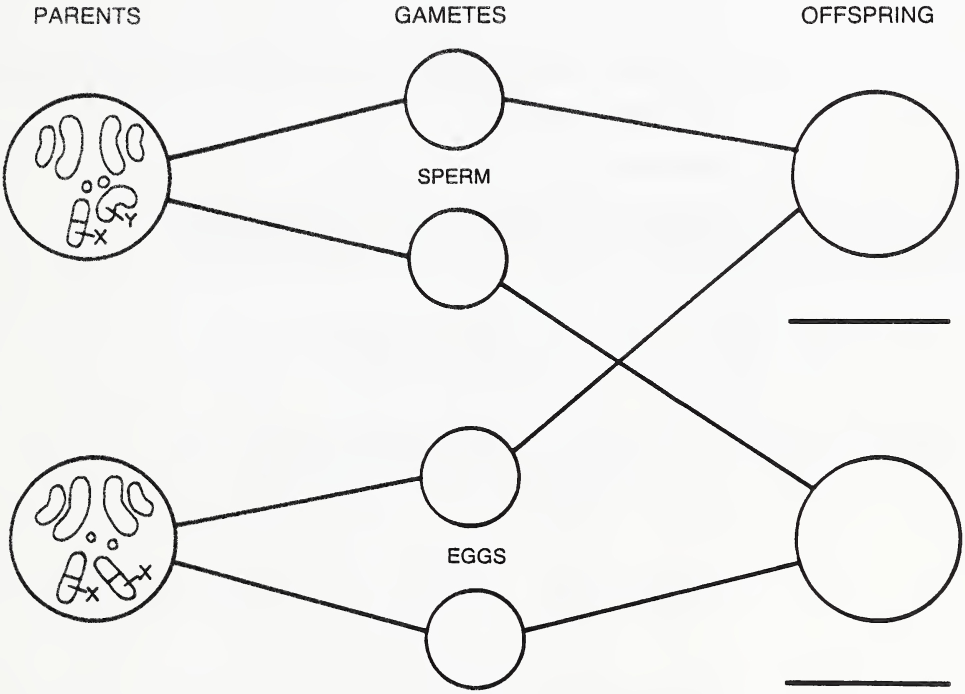
Part Two: Short Answer

1. Complete the diagram below using the following instructions.

(a) Draw all the chromosomes that would be present in the gametes and offspring (this has been done for you in the parent cells).

(b) Label the sex chromosomes (X and Y) in the gametes and offspring.

(c) Indicate the sex of the offspring on the line provided.



2. Color pigmentation (black and yellow) in the coat of cats is a sex-linked trait. As well, the two alleles are **codominant** so that a heterozygote will possess a tortoise-shell color—a mixture of black and yellow. Let X^B = black and X^Y = yellow.

   (a) Suppose you and a friend saw a tortoise-shell cat sitting on a fence post and you bet your friend it was a female. Why would this be a sure bet?

   ____

   ____

   ____

   ____

   (b) Complete the following, given a parental cross consisting of a tortoise-shell female and a yellow male (X^YY).

   Parents (P): ________ × ________

   Gametes: ______ and ______ × ______ and ______

   F_1:

   Genotypic Ratio: ____

   ____

   Phenotypic Ratio: ____

   ____

(c) Suppose a black cat is one of the parents that produced the following kittens: four black males, three black females and two tortoise-shell females. **Determine the probable genotypes of the parents** which produced these kittens.

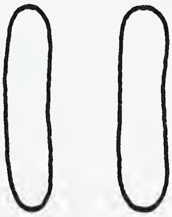
Parents (P): ________ × ________

Use the space below to work out various crosses (if necessary).

3. In tomatoes, the round type (R) is dominant to the elongated type (r) and smooth skin (S) is dominant over peach-type skin (s). A farmer cross-pollinated two tomato plants with the genotypes RrSs and rrss. He kept records of the tomatoes produced.

Round, smooth	213
Elongated, peach	198
Elongated, smooth	17
Round, peach	9

(a) Use the following diagram to illustrate how the genes are **linked** on each homologous chromosome in the RrSs parent.



(b) Linked genes, such as those shown in the above diagram, sometimes assort independently. Explain how independent assortment can occur even when genes are linked on the same chromosome.

____

____

____

____

____

4. True-breeding **long** radishes are crossed with true-breeding **round** radishes. The F_1 generation are all oval-shaped.

   (a) How do you explain the resulting phenotype in the F_1 generation?

   (b) Determine the probable genotypic and phenotypic ratios of the F_2 generation.

Submit pages 17 to 24 of this lesson for correction.

END OF LESSON 10

LESSON RECORD FORM

2230 Biology 20

Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ______________________

Time Spent on Lesson ______________________

(If label is missing
or incorrect)

File Number ______________________

Lesson Number __________

Student's Questions and Comments

Apply Lesson Label Here

Name ______________________

Address ______________________

____

____

Postal Code ______________________

Please verify that preprinted label is for correct course and lesson.

FOR SCHOOL USE ONLY

Assigned Teacher: __________

Lesson Grading: ________

Additional Grading E/R/P Code: ________

Mark: ______________

Graded by: ____________

Assignment Code: ______

Date Lesson Received:

____

Lesson Recorded ______

Teacher's Comments:

____

Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

MECHANISMS OF GENETIC CHANGE

Introduction

Just by observing the people around you, it should be obvious that no two individuals are exactly alike (except for identical twins). Various combinations of genetic traits give rise to countless phenotypic variations within a population. The phenotypic variations among the individuals of a species have been noted by scientists for a long time. Scientists could not, however, explain what caused this variation and what, if any, effect it had on the species in general.

Today, with our knowledge of genetics, we know that variation is necessary to permit a species to adapt to the ever-changing environment. Adaptations, inheritable changes within a species, usually take place over a long period. This process, by which populations change and develop adaptations is known as **evolution**. This process is not to be confused with the **theory of evolution**. The theory of evolution states that all organisms living today have evolved from related organisms that lived in the past.

This lesson begins with a discussion of theories in science, paying particular attention to the theory of evolution.

Understanding Theories in Science - Evolution

In the sciences, the scientific method is used in gathering data. This data must be testable through observation and experiment. Only after repeated verification of the data will it be accepted to account for the phenomena to which it is ascribed. It is through these methods that scientists in all fields have gathered the data that forms the basis of their work.

As scientists gather data, they often try to interpret their findings in the form of a pattern that organizes the parts into a reasonable whole. This interpretation is known as a **theory**. A theory can only take into account the data that exists at the time it is formed. Its value will depend on whether data has been distorted or omitted. As new data is compiled, it can be used to check the validity of the theory. The theory cannot be held as an absolute truth, for its validity lies only in its ability to account for new data. Inability to account for new evidence has given many a theory the scientific axe.

In the field of biology, the theory of evolution is very important because it organizes a vast amount of data into an understandable whole. Such facts as the similarities of the sequential stages of the embryonic development of many different organisms, the similarity of the biochemical pathways of different organisms and the use of nucleic acids as the genetic material of all organisms can be understood as a whole in light of the theory of evolution. This theory states that all organisms have arisen from related organisms that lived in the past.

As with all scientific theories, evolution must account for new scientific data that pertains to it or be rejected for a better alternative theory.

Special Creation and Evolution

You may be aware that there has been a long ongoing conflict between various groups on the subject of special creation and evolution. Special creation is the biblical account of the formation of human beings and all other living things through a divine act of God. Evolution states that all organisms including humans have developed from simpler forms of life and that all forms of life once had a common origin. Whether these two points of view are in conflict or harmony is something that individuals must decide on the basis of what they believe to be true.

It should be pointed out that there are many ways of gaining knowledge. The knowledge gained through science and through religion is different. The methods of accumulating data and developing theories in science are based on the scientific method. Knowledge in religion is based on faith in a system of beliefs held by a specific group, whether it be Christian, Jew, Moslem or Buddhist. Because the means of obtaining knowledge in these two fields is different, the validity of the data derived in one is not necessarily comparable to the data derived from the other. It is the inability to distinguish between data derived from these two systems that has led to the previously mentioned conflict.

Because biology is a science, data gathered in this field is restricted to the methods used in all scientific efforts. It is for this reason that the belief in special creation, derived from religious doctrine is not taught as scientific fact. This does not mean that special creation is a less valid approach to the diversity and origin of life or that evolution and special creation are incompatible ideas. Many scientists hold strong religious beliefs yet accept the fact that evolution has been adequately demonstrated without finding the two beliefs incompatible. The resolution of whether these two concepts are compatible or not is beyond the scope of this course. If you are interested in this topic there are many books available through your public library that may offer you some insight.

How Scientists Study Evolution

Most modern scientists believe that organisms presently alive have descended from a primitive ancestral stock by a process of continual change extending over great periods of time. The implications of this statement are that a process, the mechanism of evolution, controls the results of evolution and that this process has been and still is in operation.

Evolution, like any historical process, may be studied in two ways. In the first way, the general features and the past and present directions of the process may be inferred from comparative studies of the sequence of events from the past. This method involves the work of geologists, paleontologists and comparative anatomists. In the second way, one may attempt to discover the causes of evolution through a study of the causes and mechanisms that operate in the world today. This is the approach used by geneticists and ecologists. The first of these approaches is based on observation while the latter is based on experimention. Both these approaches have yielded a lot of evidence to support this important theory.

Theories of Evolution

Ideas such as *spontaneous generation* and the *immutability of species* were in vogue until the 19th Century. During the 19th Century, two theories of evolution were presented and widely accepted, at one time or another, by the scientific community. One theory was presented by Jean Lamarck in 1809 and the other by Charles Darwin and Alfred Wallace in 1858.

A. Lamarck

The first general theory of evolution was proposed by the French biologist, Jean-Baptiste Lamarck. He was also the first to show the common ancestry among different groups of living organisms by designing an evolutionary tree, with branches showing the development from microorganisms to humans. Lamarck believed that organisms change from generation to generation in response to environmental factors. To explain how these changes came about, Lamarck proposed the **law of use and disuse** in conjunction with a theory dealing with the **inheritance of acquired characteristics**.

Lamarck's law of use and disuse was based on the assumption that individual organisms could alter their physical features in response to environmental pressures. According to Lamarck, a particular organ or structure was strengthened by continuous use while continual disuse resulted in a weakening and eventual disappearance of a structure. The example most often used to illustrate the law of use and disuse concerns the giraffe.

Lamarck theorized that the long neck of the giraffe was the result of continual stretching to reach the leaves of trees while competing for food. This constant stretching, he believed, resulted in a lengthening of the giraffe's neck. Thus, the "**use**" of the giraffe's neck resulted in its elongation. Similarly, Lamarck saw structures such as the little toe on a person's foot or the muscles used for wiggling their ears as weakened, on their way to disappearing altogether, because of "**disuse**."

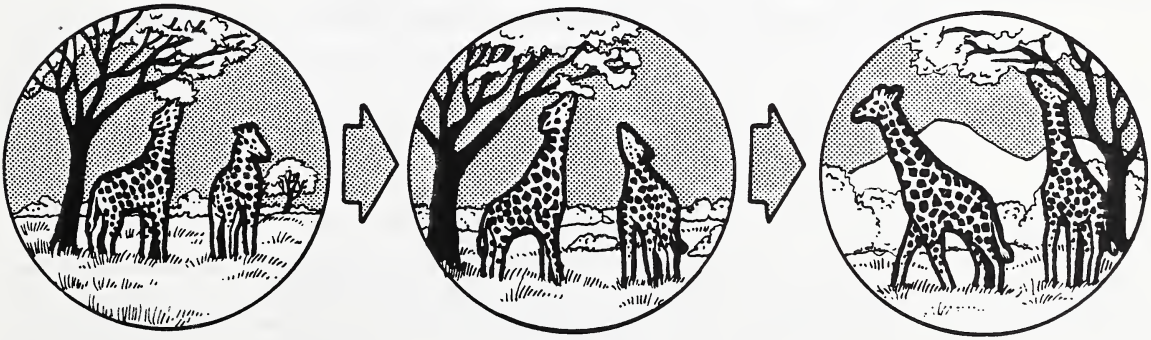


Figure 1: Lamarck's theory of evolution in giraffes. Competition for food caused the giraffe to stretch to reach leaves. Later generations inherited the longer neck.

To Lamarck, any changed feature which was either acquired or lost during an organism's life was called an **acquired characteristic**. Lamarck believed that acquired characteristics were inheritable, that is, passed on to the immediate offspring and future generations.

Of course any scientific theory is only valid as long as the existing body of knowledge does not contradict or disprove it. To test the validity of any theory, scientists rely on the processes of experimentation and observation. Lamarck's theory of evolution is not supported by observations or experimental results.

A scientist named August Weismann tested Lamarck's evolutionary theory by cutting the tails off numerous, successive generations of mice. If Lamarck's theory were correct, a type of tailless mouse should develop. Weissmann found, however, that each successive generation of mice continued to be born with tails, thus disproving Lamarck's theory of evolution.

Lamarck's theory of evolution, while incorrect, did much to aid the acceptance of evolution as a viable concept. Previous to Lamarck, the idea of immutability of a species was widely accepted. In other words, people believed that all life on earth had always existed as we know it today, that is, species did not change over time. Lamarck's theory of evolution was widely accepted by the scientific community from 1809 until 1858. In 1858, a new evolutionary theory was presented by Charles Darwin and Alfred Russel Wallace which quickly replaced Lamarck's theory as the most widely accepted theory of evolution.

B. Darwin and Wallace

READ

Read the section of your text dealing with Darwin and Wallace (p. 150).

Charles Darwin and Alfred Russel Wallace were 19th Century English naturalists who travelled extensively, examining the diverse flora and fauna of the world. Their observations led them to ask questions such as, why does the South American rhea so closely resemble the African ostrich, and how could adjacent islands, such as those found in the Galapagos, be populated by similar, though not identical, species? Darwin and Wallace found that these questions could not be answered if one accepted the idea of the immutability of a species. Both men were convinced that species change over time. Their next task was to satisfactorily explain how evolution takes place.

It is amazing that, even though Darwin and Wallace did not know each other personally and never worked together, both came up with the same explanation for how species change over time. Darwin had, in fact, developed his evolutionary theory some 20 years before Wallace, but he did not publish his conclusions until spurred on by the similarity of Wallace's theory to his own. For this reason most of the credit for the present theory of evolution has been given to Darwin.

To explain how species change over time Darwin and Wallace independently developed the **theory of natural selection**. This theory can be summarized in the following five statements:

1. All organisms produce more offspring than can actually survive.
2. There is variation amongst the individuals of a species.
3. Every organism faces a constant struggle for survival.
4. The individuals most suitably adapted to their environment survive (survival of the fittest).
5. The individuals that survive pass their traits on to their offspring.

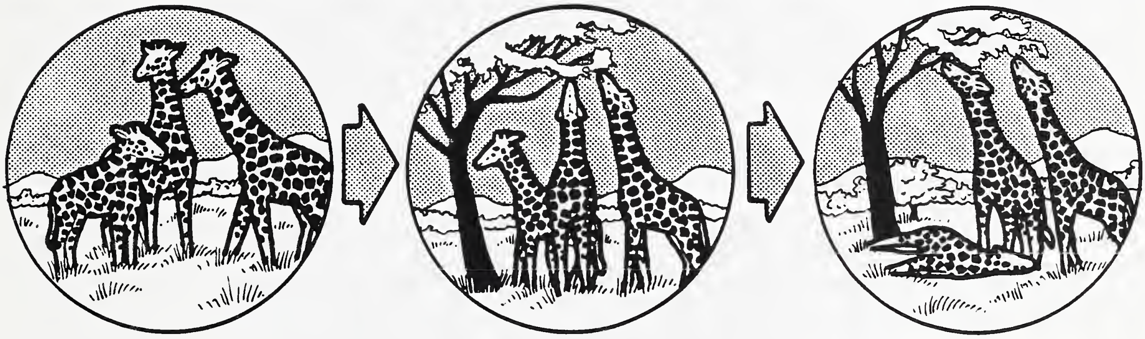


Figure 2: The Darwin-Wallace theory of evolution in giraffes. At one time giraffes exhibited a variety of phenotypes for overall body height. Over many generations the tall giraffes survived food shortages by eating leaves on high branches while the short giraffes died. Eventually, all of the short variety of giraffe disappeared and only the tall variety remained.

READ

Read the sections of your text dealing with natural selection (pp. 145 - 152).

Lamarck, Darwin and Wallace believed that the environment plays an important role in evolution. Major theoretical differences arose, though, when each explained the mechanism which caused a species to change over time. Lamarck believed that changes in the environment prompted individuals to change. That is, organisms improved or lost structures by adjusting to environmental change. Darwin and Wallace, however, believed that a species normally contains a variety of features, and when a change occurs in the environment, some of the organisms may be better adapted for survival than others. Survival then, is dependent on the chance possession of advantageous variations by individuals within a population. Darwin and Wallace realized that evolution works on the variation within populations, and not by changing the characteristics of individuals.

The Mechanism of Evolution

One year after the presentation of the Darwin-Wallace theory of evolution, Darwin published the text called the **Origin of Species**. In this publication he presented considerable evidence in support of his evolutionary theory, and was responsible for popularizing it. The following sections of this lesson will make reference to **Darwin's theory of evolution**. Darwin was the first to provide a substantial amount of evidence to support what he considered to be the mechanism of evolution—natural selection.

Darwin envisioned natural selection as a two-step process requiring, first, the production of variation and, second, the testing of this variation by the environment. He could not, however, explain the source of these variations or how they were transmitted from one generation to the next.

A. Variation

Darwin could not explain the source of the variations he observed because he had no knowledge of modern genetics. Darwin's *Origin of Species* was published seven years before Mendel published his findings on the inheritance of traits in garden peas. Mendel's work was subsequently "lost" to science until its rediscovery in 1900—eighteen years after Darwin's death. The work done by Mendel and his successors in the field of heredity provided answers regarding the source of variations and how these variations are transmitted from one generation to the next.

Individual members of some species often exhibit considerable differences in their physical and biochemical makeup. These differences, known as **variations** are of two types: the first being **environmental variations** which operate during the lifetime of an individual. Consider yourself: you may develop your athletic ability by extensive practice; your intellect by education, or your health by correct diet. These activities have **no genetic component** and thus, are not passed on from generation to generation. Biological evolution, then, does not occur by exercise, education or diet.

The second type of variation is known as **genetic variation**. This is caused by different combinations of genes along the chromosomes. Different gene combinations (genotypes) are responsible for the variety of phenotypes present in all populations. Natural selection works to reduce genetic variability by weeding out those individuals whose characteristics are nonadaptive or of no value for survival. This decrease in variability is countered by two processes which increase genetic variability—**sexual recombination** and **mutation.**

Sexual recombination is a byproduct of the processes required for sexual reproduction. During meiosis, random assortment of the homologous chromosomes on either side of the equatorial plate results in the production of gametes containing a reshuffled combination of chromosomes. Fertilization (the union of gametes) also adds to the genetic variability, since maternal and paternal genes interact to produce new phenotypes. Remember, the chromosomes of most kinds of organisms contain tens of thousands of genes, each of which may have several alleles. This results in almost limitless possibilities for the recombination of alleles to produce individuals with different genetic patterns.

Mutation is the only source of new genes. Mutations to chromosomes in the germ cells (gametes) are the raw material for genetic change. Mutations occurring in the somatic cells have little effect in sexually reproducing species because they are not passed on when gametes are formed.

Mutations were first recognized as the main cause of organic variation by the Dutch botanist **Hugo De Vries**. De Vries presented his mutation theory of evolution in 1901, after many years of research involving primrose plants. De Vries examined some 50,000 plants over the years and found that at least 800 possessed striking new traits not present in the parents. These proved to be inheritable changes, since De Vries found that future generations of these mutants also possessed the new traits. From this evidence De Vries concluded that mutations must occur in other organisms besides primrose plants. Change by mutation, he believed, was the basis for evolution.

Today, with advances in the field of genetics, scientists have a better understanding of the theory first offered by De Vries. We now know that inheritable mutations must occur in the genetic material (chromosomes) of the germ cells. These mutations can be categorized according to the type of alteration which occurs within the genetic material. The four basic types of mutation are: chromosome multiplication, chromosome fragmentation, repetition and gene mutation.

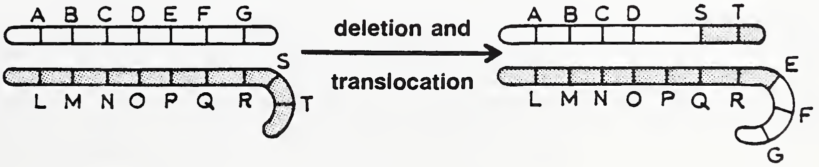
Chromosome multiplication occurs when there is an irregularity in cell division resulting in a fluctuation in the number of chromosomes from the normal diploid number (2n) to three times the haploid number (triploid), four times the haploid number (tetraploid), or an even higher number. The resulting individuals of this type of mutation are known as **polyploids**. Polyploid plants are generally larger than the parent plants; they often have large stems, leaves, flowers and fruits. Commercial growers often apply the chemical **colchicine** to induce polyploidy and produce large varieties of watermelons, marigolds, bananas and snapdragons.

Chromosome fragmentation is a type of chromosomal mutation in which the number of chromosomes remains constant while alterations in structure take place in one or more of the chromosomes. Chromosome fragmentation can occur by deletion, translocation, duplication or inversion.

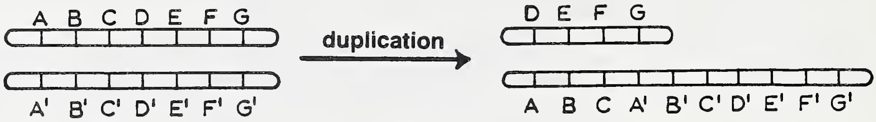
Deletion occurs when a piece of chromosome breaks off and becomes lost.

Translocation occurs when the broken-off piece of chromosome becomes attached to a *non-homologous* chromosome.

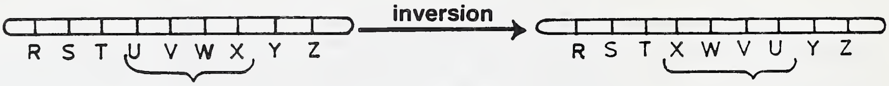
e.g.



Duplication occurs when the broken-off piece of chromosome becomes attached to the *homologous* chromosome.



Inversion occurs when the broken-off piece of chromosome becomes *reversed* and is subsequently *joined on again.*



The end result of the above cases is a rearrangement of the linear order of the genes. These rearrangements are different from the normal process of crossing-over, which takes place between the chromatids formed from different but homologous chromosomes.

Repetition is the result of reduplication of portions of the DNA in a chromosome. Repetition, apart from polyploidy, is the only mechanism known whereby an increase in the number of genes in a chromosome can be achieved.

Gene mutations occur when there is a spontaneous change in the basic genetic code at a single gene locus without any corresponding change in the number or structure of the chromosomes. The locus is the position of a gene within a chromosome. The removal or addition of a single nucleotide will result in improper readings of the remaining codons in the DNA strand. Changing the nucleotides in a DNA molecule changes the information coded therein, resulting in gene mutations.

Gene mutation is the only means by which new alleles may be formed. These new alleles often produce an entirely different version of a phenotype for a specific trait, thus adding to the existing number of variations within a population.

Sickle-cell disease is a genetic blood disorder that affects the hemoglobin in a person's blood. People with sickle-cell disease have crescent- or sickle-shaped red blood cells instead of the normal round variety. This disease is the result of a gene mutation in which only one nitrogenous base is changed along a DNA molecule. Remember, each molecule of DNA possesses tens, or even hundreds of thousands of nitrogenous bases. The changed nitrogenous base results in the production of a different amino acid in one of the four protein chains which make up a hemoglobin molecule. This small change results in a different three-dimensional arrangement of the proteins, giving rise to a crescent-shaped red blood cell.

More information regarding sickle-cell disease can be found in your text (pp. 125 - 127).

The causes of gene mutations are still unknown though their rate of occurrence can usually be increased by artificial exposure to certain kinds of radiation, various chemicals or changes in temperature. These agents, however, are not selective for inducing mutations at a specific locus.

To summarize, mutation and genetic recombination provide the genetic variability upon which natural selection can act to produce evolutionary change. Natural selection can act on genetic variation only when the variation is visible (i.e. a phenotypic change). A recessive allele (which is not expressed in the phenotype of an organism) cannot be affected by natural selection.

B. Natural Selection

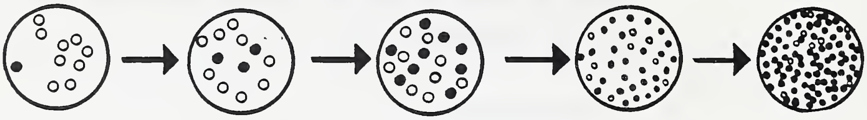
Review the sections of your text dealing with natural selection (pp. 145 to 152).

As you have seen, a potentially large source of genetic variability can exist in the members of a population because of sexual recombination and mutation. Natural selection acts on these genetic variations, weeding out those individuals possessing non-adaptive or harmful variations and permitting those individuals with adaptive or beneficial variations to survive and reproduce.

The principal factor in natural selection, as identified by Darwin and Wallace, is the environment. In developing the theory of natural selection, Darwin and Wallace proposed that most of the living things born into an environment would die before they could reproduce. This is because the resources available to each species are limited. Limited amounts of food, water and space force all individuals in each species into a **struggle for existence**. Naturally, those individuals which are better adapted to the particular environmental conditions will survive to reproduce while others will die.

The example given in your text concerning DDT and flies (p. 149) illustrates the role of the environment in natural selection. The use of DDT as a pesticide changed the particular environmental conditions in which the flies had to survive. Those flies which happened to have a "built-in" immunity to DDT were able to survive and reproduce while the majority of the housefly population was killed. Thus, those houseflies which possessed the built-in immunity to DDT were the **fittest** individuals of the population.

The phrase, **survival of the fittest**, has often been used in connection with Darwin's theory of natural selection. This phrase has often been misinterpreted because it implies that the biggest, meanest and toughest individuals are the fittest. Wrong! The **fittest organisms** in any population are those that leave the **largest number of mature offspring**. Those houseflies which survived repeated sprayings of DDT and went on to produce mature offspring may have been the smaller, slower and weaker individuals of the population. Natural selection is, in effect, *differential reproduction*. Those individuals which produce the most viable offspring will determine a greater percentage of the next generation and thus are the "fittest."



Parental Generation	First Generation	Second Generation	Third Generation	Fourth Generation
1/10 = 10%	3/12 = 25%	9/18 = 50%	27/36 = 75%	81/90 = 90%

Figure 3: A variation arises in one individual of the parental generation (black dot) enabling this organism to leave three offspring. Each of the normal individuals (white dots) is only able to leave one offspring. Notice how the reproductive advantage of the variant leads to a progressively larger fraction of the variant type within the population. The spreading of such variations brought about by differential reproduction, constitutes natural selection.

Speciation

You have already seen, in previous sections of this lesson, that inheritable characteristics or variations can spread throughout an entire population over time, resulting in changes in the genetic makeup of the population. This process, by which populations change and develop adaptations, is one of the two processes involved in the theory of evolution.

The second process required to support the theory of evolution involves the formation of new species. If we assume that life on the earth originated only once, then all existing species of plants, animals and microbes must have stemmed from some common ancestor. If this is so then the theory of evolution, to be valid, must be able to explain how new species are produced.

READ

Read the section of your text which deals with the concept of species (pp. 166 and 167).

Individual organisms can be grouped into larger units known as species. A **species** is a group of organisms which normally interbreed in nature to produce fertile offspring. Each species is reproductively isolated from other such groups and the interbreeding of species does not usually occur in nature. Many separate species have been crossed in captivity to produce hybrids, but these are unnatural occurrences which often result in sterile offspring. The key to the definition of a species is **reproductive isolation under natural conditions**.

Reproductive isolation is also the key to the formation of new species. **Speciation**—the establishment of new species—cannot occur when there is a free flow of genes throughout the populations of a species. An absence of barriers to prevent free gene flow means that any new, advantageous genes would quickly be incorporated into the genetic makeup of the entire species. Reproductive barriers within a species permit environmental variations and mutations to bring about genotypic and phenotypic changes in isolated populations of a species. If these populations remain reproductively isolated from others of the same species for a long period, the cumulative effect of the genetic variations may be so great that these populations will have become incapable of interbreeding with the original, parent species. Thus, speciation, or the formation of a new species, will have occurred.

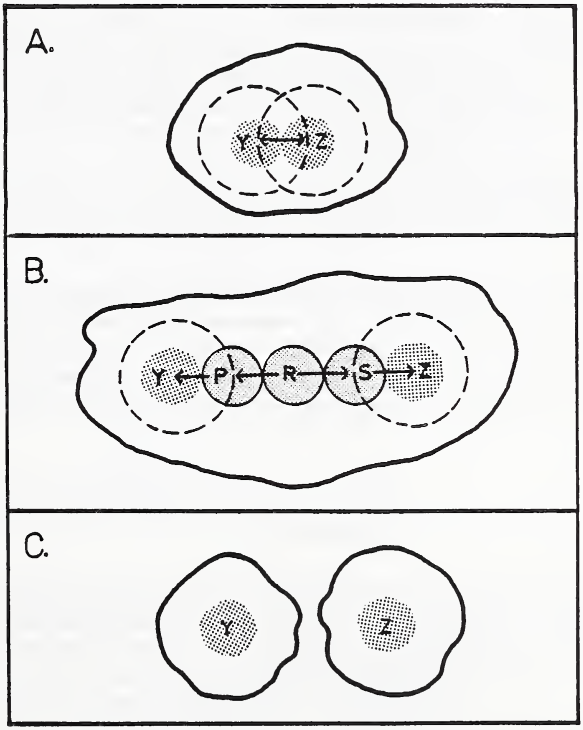


Figure 4: Speciation. A. Two populations (Y, Z) of the same species have overlapping reproductive ranges (dashed circles) and, therefore, direct gene flow. B. Population growth and territorial expansion have resulted in separate reproductive ranges for Y and Z. Gene flow between them is now indirect, via intervening populations (P, R, S). C. Gene flow between Y and Z ceases, resulting in reproductive isolation and eventually separate species.

It is known that for a new species to evolve there must be a division that isolates a population. You will now examine some of the mechanisms responsible for the reproductive isolation of populations.

A. Geographical Isolation

For two populations to diverge genetically onto different evolutionary pathways which eventually lead to the formation of new species they, as a rule, must first become geographically isolated from each other. This can occur when barriers come between two populations of a species. Obstacles that prevent the dispersal of a species, such as deserts, mountains, forests and oceans are often considered to be natural barriers.

Whether or not an obstacle is a barrier to a species depends on its **method of dispersal**. For example, suppose that during a period of exceptionally high water, a species of fish is able to disperse by swimming into a lake that is not normally connected to the river where it lives. When the water level returns to normal, the land between the lake and river forms a **geographical barrier**, isolating the species into two populations.

If a large population is separated into two or more parts which are geographically isolated, the independent parts can follow different courses of evolution. That is, isolated populations do not follow any set pattern for evolutionary change since evolution is the result of natural selection pressures on randomly occurring genetic variations. The following reasons for different evolutionary pathways provide a more detailed explanation of this phenomenon:

1. Different mutations appear in separated groups of organisms, providing the basis for genetic variability.
2. The mutations and recombinations which appear in separated populations will have different adaptive values in different environments.
3. The individuals forming an isolated population may not be representative of the population from which they came, thus different gene frequencies will exist in the population from the start.
4. The size of a new population may become quite small at times, leading to fluctuations in the frequency of genes in the gene pool due to chance. This is known as **genetic drift**.

Much genetic change can occur in a population without it transforming into different species. Populations within a species that exhibit varying degrees of genetic differences in their gene pools are known by such terms as races, subspecies, varieties, strains and breeds. All of these groups are interfertile with members of other populations though the frequency of the genes in each population may vary.

B. Nongeographical Isolation

You have already seen that evolutionary changes can occur in populations that have become isolated by geographical barriers. These evolutionary changes, combined with the effects of potentially different environments, can lead to the formation of **nongeographical barriers** to reproduction.

Nongeographical barriers do not require the physical separation of two populations to prevent interbreeding. That is, the geographical ranges of various populations can overlap without any occurrence of interbreeding. These nonphysical barriers, then, are usually a more permanent means of separating populations which are on their way to becoming separate species.

Nongeographical isolation can be achieved in four major ways:

1. ecological isolation
2. seasonal isolation
3. physiological isolation
4. behavioral isolation

In Ontario, there are two populations of the deer mouse (*Peromyscus maniculatus*). One of these inhabits the wooded areas around the Great Lakes, while the other inhabits the shoreline. Between the shore and woods are grassy meadows that both populations avoid. Therefore, these two populations rarely meet, and consequently interbreeding is kept to a minimum. This, then, is a case of **ecological isolation**, since the two populations of deer mouse are isolated because they live in different habitats.

Populations can also be separated by **behavioral isolation**. Populations of Pacific salmon exhibit this type of reproductive isolation by always swimming upstream to breed in the headwaters of the stream in which they were born. Thus, even though salmon have lived together for years in the ocean, they are not a freely interbreeding population. They are genetically separated by behavioral isolation.

Seasonal isolation occurs when two populations breed at different times of the year. Plants that flower in early May will be reproductively isolated from any populations which flower in late June.

Populations are **physiologically isolated** when there is a functional incompatibility in mating or in the production, fertilization, or survival of gametes. A horse can be crossed with a donkey to produce an offspring known as a mule. The male mule, however, is sterile, thus preventing the mating of two mules to produce more mules. Horses and donkeys, then, are considered to be separate species due to physiological differences.

Polyploidy

One million years. Scientists have estimated that this is the normal length of time required for speciation. In nature, speciation is seen as a slow, steady process involving the random appearance of genetic variations and the ever-present selection pressures of the environment. This does not, however, rule out the sudden appearance of new species.

The abrupt origin of a species can take place when meiosis is so abnormal that it results in the formation of more than one complete set of chromosomes in a gamete. The union of this gamete with another may produce a zygote with three, four, five, six, or even more, complete sets of chromosomes. This is called **polyploidy** and makes it possible for the parent to belong to one species and its offspring to another. This process is rare in animals but common in some plants where it often causes greater hardiness and larger size.

EXERCISES TO BE SENT IN FOR CORRECTION

Part One: Multiple Choice

For each of the following questions, choose the best answer and write the appropriate letter in the blank provided.

______ 1. According to Lamarck's theory of evolution, which of the following would be most correct? The giraffe developed a long neck because

(a) it needed one and such a neck was passed on to the offspring.
(b) giraffes with long necks had a better chance to survive than those with shorter necks.
(c) a giraffe was born with a sudden change in neck length not present in either parent.
(d) long-necked males were more successful in attracting mates.

______ 2. The offspring of a rat which has lost its tail will be born without tails. Those who agree with this statement follow the doctrine of

(a) natural selection.
(b) the inheritance of acquired characteristics.
(c) the law of use and disuse.
(d) survival of the fittest.

______ 3. What did Darwin and Wallace base their theory of evolution on?

(a) survival of the fittest
(b) the use and disuse of organs
(c) genetic variations
(d) environmentally acquired characteristics

______ 4. The greatest weakness of the Darwin-Wallace theory of evolution was a failure to give a satisfactory explanation for

(a) overpopulation.
(b) the struggle for existence.
(c) the survival of the fittest.
(d) genetic variation.

______ 5. If a species lives in an area which for centuries has been inhabited by a large number of predators and if this species has no means of defence other than running, you would expect that the members of this species would

(a) develop stronger legs because of excessive use.
(b) be killed if they were slow, allowing natural selection to occur.
(c) develop longer legs because of much use.
(d) mutate in such a way as to cause longer legs to be produced in response to the animal's needs.

_____ 6. Which of the following statements is part of the Darwin-Wallace theory of natural selection?

(a) Acquired traits are inherited, based on use and disuse.
(b) Natural selection causes variations to occur in species.
(c) Competition between organisms occurs due to limited resources.
(d) Variations between organisms are quite rare, and thus significant.

_____ 7. In modern evolutionary theory, sexual reproduction is a significant factor primarily because it provides for

(a) great variation in offspring.
(b) the only means for the continuation of the species.
(c) changes in the way in which DNA duplicates itself.
(d) the production of genes.

_____ 8. The snowshoe hare is a mammal found throughout Alberta in wooded and bushy areas. In winter its fur is white but in summer it is a grizzled brown. Which of the following statements would most accurately explain this phenomenon?

(a) White fur keeps the hare warm in water by reflecting the cold.
(b) The hare likes to change its color twice yearly.
(c) White and brown mammals are best suited for life in bushy areas.
(d) The color change gives the hare greater protection.

_____ 9. Which of the following statements would be the most reasonable explanation for how the hare developed this color change?

(a) In winter all the brown hares are killed by predators.
(b) The type of food in the hare's environment causes the color change.
(c) Over a long period, a series of mutations had selective value.
(d) Continuous exposure to snowy conditions produced the change.

_____ 10. Which of the following is an example of natural selection?

(a) When the food supply grew scarce, giraffes developed longer necks to reach the higher leaves on trees.
(b) Penicillin was introduced into a bacteria culture. The most resistant bacteria survived and produced offspring resistant to penicillin.
(c) Even though Weissmann cut off the tails of mice, succeeding generations of mice were born with tails.
(d) As the earth's climate became colder, woolly mammoths adapted by growing thicker coats of fur.

______ 11. If a mutant gene is harmful and recessive, which individuals of a population possessing the gene would be selected against by the environment?

(a) the original organism in which the mutation first occurred
(b) all individuals in the population possessing the mutant gene
(c) all individuals in the population heterozygous for the gene
(d) all individuals in the population homozygous for the gene

______ 12. An animal has an allele that gives it a survival advantage. Over time an increase in the percentage of this allele in the population would probably be due to

(a) use and disuse.
(b) mutation.
(c) natural selection.
(d) artificial selection.

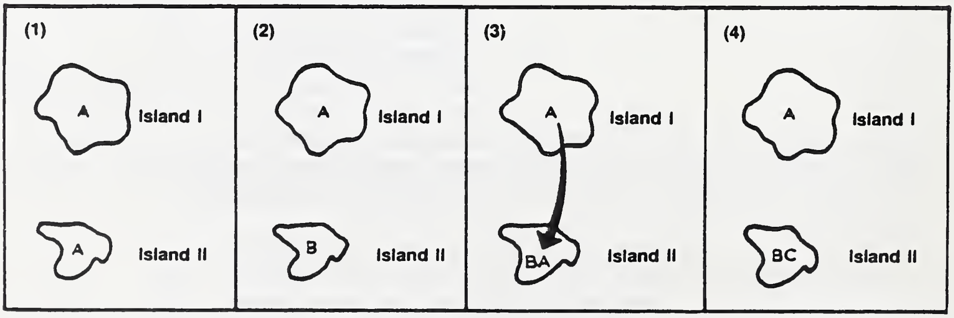
______ 13. It is believed that several species of finches on the same island all developed from a common ancestor. This speciation was probably due to

(a) geographical isolation.
(b) ecological isolation.
(c) behavioral isolation.
(d) time.

______ 14. A useful mutation would spread more rapidly in a housefly population than a human population because

(a) flies are much smaller than humans and consequently need less food.
(b) flies reproduce asexually and humans reproduce sexually.
(c) flies produce more offspring and have a shorter life span than humans.
(d) all the above.

Use the information given below to answer questions 15 to 17.



A represents an ancestral form of bird that inhabited Islands I and II.

______ 15. After being isolated from each other, Type **A** birds on Island I were unable to breed with the birds on Island II. Type **B** birds would then be considered a new

(a) race.
(b) species.
(c) genus.
(d) family.

______ 16. In diagram (3), some individuals of **A** colonize **B**'s island. If **A** and **B** are no longer interfertile, over time, the most likely results would be that

(a) Type **A** would take over the island since it is the ancestral form.
(b) hybrids would form.
(c) Type **A** would return to Island I due to overpopulation.
(d) Type **A**, with different feeding and nesting habits from **B** would increase in number.

______ 17. Examine diagram (4) which shows the result of Type **A**'s colonization of Island II. It would be logical to infer that birds of Type **C** are

(a) a hybrid of Types **A** and **B**.
(b) the same species as Type **A**.
(c) the same species as Type **B**.
(d) different species from Types **A** or **B**.

______ 18. The Abert squirrel lives on the south rim of the Grand Canyon. This squirrel can, but rarely does, interbreed with the Kaibab squirrel on the north rim of the canyon. Which of the following statements is **false**?

(a) The Grand Canyon is a barrier separating the two types of squirrels.
(b) The two types of squirrels are probably closely related species.
(c) The two types of squirrels may have developed from the same ancestral species.
(d) The two types of squirrels represent two distinct, unrelated species.

______ 19. Africa and Madagascar are separated by a narrow strait. Animals and plants common on the mainland of Africa are not found on the island. This fact illustrates the principle of

(a) incomplete dominance.
(b) evolutionary equilibrium.
(c) evolution in isolated populations.
(d) succession.

______ 20. Genes which are harmful and recessive can remain in a population of organisms because they are

(a) kept for future survival value.
(b) passed on to offspring through sexual recombination.
(c) only eliminated by an increase in mutation rate.
(d) carried by individuals that are heterozygous.

Part Two: Matching and Fill in the Blanks

1. Match the following by choosing the correct letter from Column II and placing it in the appropriate blank in Column I. **Do not** use any letter more than once.

	Column I		Column II
______	was the first to recognize that mutations were the main cause of organic variation.	A.	August Weismann
______	designed the first evolutionary tree.	B.	Jean Lamarck
______	the lesser known of two men who independently developed the theory of natural selection.	C.	Hugo De Vries
______	disproved an evolutionary theory by cutting the tails off numerous, successive generations of mice.	D.	Gregor Mendel
______	author of the text entitled the "Origin of Species."	E.	Charles Darwin
		F.	Alfred Wallace

2. Complete each of the following statements by filling in the numbered blank on the right.

(a) For any data to be acceptable to science it must be testable through __(1)__ and __(2)__.

(1) ____________________

(2) ____________________

(b) Lamarck's theory of evolution was based on the inheritance of __(3)__ __(3)__ (two words).

(3) ____________________

____

(c) Darwin could not explain the source of variation within populations because he had no knowledge of modern __(4)__.

(4) ____________________

(d) Individual variations can be of two types; __(5)__ or __(6)__ variations.

(5) ____________________

(6) ____________________

(e) __(7)__ in the germ cells (gametes) are the raw material for genetic change.

(7) ____________________

(f) __(8)__ occurs when a section of one chromosome breaks off and becomes attached to a non-homologous chromosome.

(8) ____________________

(g) __(9)__ occurs when a section of a chromosome breaks off and becomes lost.

(9) ____________________

(h) __(10)__ occurs when a section of one chromosome becomes attached to the homologous chromosome. (10) ____________________

(i) Changes in the nucleotides of a DNA molecule changes the information that is coded therein, resulting in __(11)__ mutations. (11) ____________________

(j) The gene for sickle-cell disease is common in persons of African descent because it offers some protection against __(12)__. (12) ____________________

(k) Instantaneous speciation that does not require any form of isolation of populations for the development of genetic isolation, but rarely occurs in animals is known as __(13)__. (13) ____________________

(l) A __(14)__ is a group of organisms which normally interbreed in nature to produce fertile offspring. (14) ____________________

(m) __(15)__ barriers are those which do not require the physical separation of two populations to prevent interbreeding. (15) ____________________

Part Three: Short Answer

1. The process by which a population becomes adapted to its environment is called natural selection. How does this process work?

____

____

____

____

____

____

2. The dandelion is a self-pollinating plant.

   (a) What advantage would this have for this species in a relatively stable environment?

   (b) If dandelions remained self-pollinating, how could genetic variation develop to meet the demands of a changing environment?

3. Describe how genetic isolation could develop between two populations of the same species once they have become separated by a geographical barrier.

4. Would somatic mutations play a significant role in modifying the heritable characteristics of a sexually reproducing population? Explain your answer.

5. List three mechanisms that maintain genetic isolation between closely related species that inhabit the same environment and explain how each works.

(a) ______________________________

____

____

(b) ______________________________

____

____

(c) ______________________________

____

____

Submit pages 14 to 21 of this lesson for correction.

END OF LESSON 11

LESSON RECORD FORM

2230 Biology 20

Revised 88/10

FOR STUDENT USE ONLY

Date Lesson Submitted ______________________

Time Spent on Lesson ______________________

(If label is missing or incorrect)

File Number ______________________

Lesson Number __________

FOR SCHOOL USE ONLY

Assigned Teacher: ________

Lesson Grading: ________

Additional Grading E/R/P Code: ________

Mark: ________

Graded by: ________

Assignment Code: ________

Date Lesson Received: ________

Lesson Recorded ________

Student's Questions and Comments

Apply Lesson Label Here

Name ______________________

Address ______________________

____

____

Postal Code ______________________

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____

Correspondence Teacher

St. Serv. 1-86

ALBERTA CORRESPONDENCE SCHOOL

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a **green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.**

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

REVIEW

Introduction

You are now nearing completion of the course. Your efforts should now be applied to preparing for the final test. If you have conscientiously worked your way through the course by developing your own answers and by studying your teacher's comments and additional notes, the final test should present no problem. Certainly, there will be questions which will seem difficult but there will also be many you will find quite easy. Always go into a final test with a positive attitude about your ability to pass. **Think positively**!

Purpose of Tests

There are many ways of testing and testing is done for various purposes. Generally final tests are set up to test basic understanding of terms and principles, and the ability to apply these to various situations.

Types of Questions

The types of questions students find on final tests can range from multiple choice to single-sentence to complete essay-type. The type of question is determined to a great extent by what is being tested for.

The final test you will be writing will consist of 100 multiple choice questions. This type of question requires very little written response on your part, but considerable ability to apply principles, interpret data, and make decisions between several choices of answers, each of which may be somewhat correct but one of which is more correct. However, if you have been conscientious about your course work, you should have no problem with the final test.

Course Review

Every student has their own favorite method of review and it is difficult to say one is better than another because a technique which works well for one person may not work at all for another. However, here are two suggestions:

1. Begin your review by starting at the beginning of the course and going over the material in the textbook, correspondence teaching notes, the questions in the lesson and your teacher's comments, as well as any notes you have made during the course.

2. As you go through the material, try to recall the general concepts, ideas and principles of biology developed in the course. Do not neglect detailed information. Learn to use your reference material quickly and efficiently.

This Lesson

There are two basic purposes for doing this lesson.

1. To act as a review for Biology 20.
2. To acquaint you with the techniques used in final tests.

The following are suggestions for doing this review.

1. Allow yourself a maximum of two hours to do the review. These two hours should be in a single block of time, similar to the time allowed for the final test.
2. All the questions are multiple choice. You are to select the letter of the **best choice** from the four alternatives and place it in the space at the left of each question.

   Note: The technique for recording your answer on the final test may vary from the above so **read the instructions on the final test paper carefully before you begin the final test.**
3. Many of the problems require application of principles of biology. You will have to determine your choice of answer by carefully considering ideas rather than just remembering facts.
4. Read each question carefully to be sure you understand exactly what is being asked or stated. Then consider each of the alternatives presented and select the best response.
5. Complete all the questions. Pace yourself, giving maximum time to each question without spending too much time on any one area of the review.

   Note: On the final test there is a two-hour time limit. Use it all. If you finish early, use the remaining time to check your answers.

Final Reminder

You should submit Lesson 6 before taking the final test so that it can be used in calculating your final mark. Also, if you have not returned the videotapes from the ecology section of the course, please do so.

We wish you the best of luck on the final test and in your future endeavors. If you have done a substantial amount of work to this point, your reward should be a good mark in the course.

For each of the following questions, choose the best answer and write the appropriate letter in the blank provided.

______ 1. Which of the following lists indicates increasing complexity of organization?

(a) organelle → cell → compound → tissue
(b) community → population → species → ecosystem
(c) element → compound → cell → organelle
(d) organism → population → community → ecosystem

______ 2. *Esox lucius* is best described as

(a) an individual.
(b) an population.
(c) an organism.
(d) a species.

______ 3. The increases in size of a population are most likely due to

(a) immigration and emigration.
(b) natality and mortality.
(c) natality and immigration.
(d) mortality and emigration.

______ 4. In a population that exhibits homeostasis, population numbers

(a) stay more or less the same.
(b) increase rapidly.
(c) increase slowly.
(d) decrease.

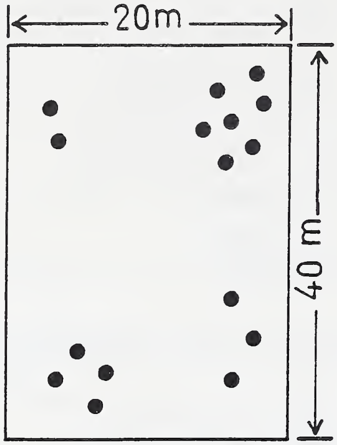
______ 5. In a closed population there is no

(a) nutrition.
(b) emigration.
(c) natality.
(d) mortality.

______ 6. A population consists of

(a) all the individuals in a given area.
(b) different individuals in an area at a given time.
(c) many groups of individuals at different times.
(d) similar individuals in an area at a given time.

The dots in the diagram below represent the location of spruce trees on a lot.



space for rough work

______ 7. What is the density of spruce trees on the lot shown above?

(a) 0.002 spruce trees per m^2

(b) 0.02 spruce trees per m^2

(c) 0.2 spruce trees per m^2

(d) 2 spruce trees per m^2

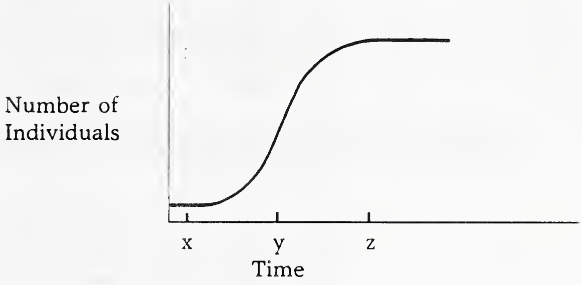
______ 8. A population decreases by 12 individuals per year. This is an example of

(a) rate.
(b) density.
(c) population fluctuations.
(d) homeostasis.

______ 9. Which of the following is **not** a type of natality?

(a) fission
(b) budding
(c) growth
(d) parthenogenesis

Use graph below to answer question 10.



_____ 10. When point z on the time scale is reached, biotic potential

(a) exceeds environmental resistance.
(b) is equal to environmental resistance.
(c) is less than environmental resistance.
(d) activates environmental resistance.

_____ 11. Which of the following is not an abiotic factor?

(a) bacteria
(b) soil
(c) topography
(d) gravity

_____ 12. The way an organism lives or its status in a community is known as its

(a) habitat.
(b) niche.
(c) range of tolerance.
(d) distribution.

_____ 13. The biotic and abiotic components of all ecosystems are composed of

(a) energy.
(b) cells.
(c) matter.
(d) carbon dioxide.

_____ 14. Substances that consist of carbon atoms linked to hydrogen atoms are

(a) elements.
(b) inorganic compounds.
(c) organic compounds.
(d) mixtures.

______ 15. By weight, living things are composed mostly of

(a) bone.
(b) carbohydrate.
(c) protein.
(d) water.

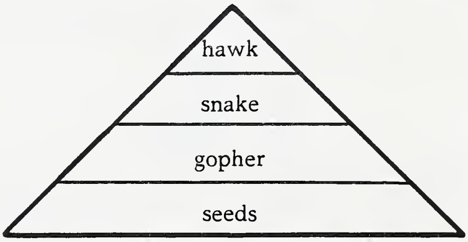
______ 16. Which of the flowing sequences describes the pathway of energy through living systems?

(a) heat → light energy → chemical energy
(b) light energy → chemical energy → heat
(c) light energy → heat → chemical energy
(d) chemical energy → heat → light

______ 17. The relationship (poplar leaf → tent caterpillar → robin) best represents a

(a) food chain.
(b) energy pyramid.
(c) food web.
(d) carbon cycle.

Use the following energy pyramid to answer question 18.



______ 18. The trophic level with the greatest amount of energy is the

(a) hawk.
(b) snake.
(c) gopher.
(d) seeds.

______ 19. As one proceeds from one trophic level to the next there is

(a) more energy available.
(b) less energy available.
(c) about the same amount of energy available.
(d) more matter available.

______ 20. The feeding relationships that exist in an ecosystem are best expressed by

(a) an energy pyramid.
(b) a food chain.
(c) a food web.
(d) a carbon cycle.

______ 21. The niche of a bear can best be described as that of a

(a) herbivore.
(b) carnivore.
(c) omnivore.
(d) scavenger.

______ 22. A relationship in which two species harm each other is known as

(a) mutualism.
(b) competition.
(c) parasitism.
(d) predation.

______ 23. In an aquarium that contains a snail and an elodea plant, the snail provides the plant with

(a) CO_2.
(b) O_2.
(c) H_2O.
(d) glucose.

______ 24. In biogeochemical cycles matter is returned to the earth and atmosphere by

(a) producers.
(b) herbivores.
(c) carnivores.
(d) decomposers.

______ 25. The substance that exhibits a sedimentary-type biogeochemical cycle is

(a) carbon dioxide.
(b) calcium.
(c) nitrogen.
(d) water.

______ 26. When succession takes place on bare rock this is known as

(a) primary succession.
(b) secondary succession.
(c) a seed stage.
(d) tertiary succession.

______ 27. The end product of a sere is a

(a) primary community.
(b) secondary community.
(c) seral stage.
(d) climax community.

______ 28. The kiwi is only found on the island of New Zealand. New Zealand is the kiwi's

(a) niche.
(b) geographic range.
(c) primary community.
(d) both (a) and (b).

______ 29. As succession proceeds, species diversity usually

(a) increases.
(b) decreases.
(c) remains about the same.
(d) depends on the rate at which the process occurs.

______ 30. A biome composed of a diversity of vegetation zones within close proximity of one another occurs in the

(a) grassland.
(b) taiga.
(c) mountains.
(d) tundra.

______ 31. The biome that is restricted to Western Canada is the

(a) taiga.
(b) tundra.
(c) boreal forest.
(d) grasslands.

______ 32. An ecotone that is found in Alberta is the

(a) taiga.
(b) grasslands.
(c) Aspen Parkland.
(d) all the above.

______ 33. In the taiga of Alberta the predominant tree species in muskeg sites are

(a) white spruce and aspen poplar.
(b) black spruce and tamarack.
(c) jackpine and lodgepole pine.
(d) willow and alder.

______ 34. The plants and animals of the mountains most closely resemble the biota of the

(a) tundra.
(b) taiga.
(c) Aspen Parkland.
(d) grassland.

______ 35. A spring is a part of the

(a) lotic habitat.
(b) lentic habitat.
(c) marine habitat.
(d) terrestrial habitat.

______ 36. The end product of succession in an oligotrophic lake is a

(a) terrestrial ecosystem.
(b) bog.
(c) swamp.
(d) eutrophic lake.

______ 37. Sphagnum moss and sedges are vegetation characteristic of

(a) swamps.
(b) sloughs.
(c) bogs.
(d) lakes.

______ 38. Most of the lakes in Alberta are

(a) tectonic lakes.
(b) oxbow lakes.
(c) of glacial origin.
(d) of volcanic origin.

______ 39. In deep lakes at mid-latitudes the thermocline

(a) does not exist.
(b) disappears in the summer and winter.
(c) is below the hypolimnion.
(d) develops due to thermal stratification.

______ 40. The most productive lakes are

(a) very cold and deep.
(b) have rocky bottoms and clear water.
(c) oligotrophic lakes.
(d) eutrophic lakes.

______ 41. Aquatic animals that are good swimmers are part of the

(a) nekton.
(b) neuston.
(c) periphyton.
(d) benthos.

______ 42. In the marine habitat most productivity is a result of

(a) benthic producers.
(b) phytoplankton.
(c) red algae.
(d) kelp.

______ 43. From top to bottom one would pass through the

(a) abyssal zone to the aphotic zone to the euphotic zone.
(b) aphotic zone to the abyssal zone to the euphotic zone.
(c) euphotic zone to the aphotic zone to the abyssal zone.
(d) euphotic zone to the neritic zone to the aphotic zone.

______ 44. The current human world population is approximately

(a) 3 billion and growing at a rate of 1.5%.
(b) 4 billion and growing at a rate of 1.7%.
(c) 5 billion and growing at a rate of 2%.
(d) 6 billion and growing at a rate of 2.5%.

______ 45. The limiting factor likely to have the most immediate effect on human world population numbers is

(a) food.
(b) water.
(c) wildlife.
(d) fossil fuel.

______ 46. As the human world population increases

(a) resource depletion will occur.
(b) desertification will occur.
(c) deforestation will occur.
(d) all the above.

______ 47. The earliest form of subsistence practised by humans was

(a) fishing.
(b) hunting and gathering.
(c) herding.
(d) farming.

_____ 48. Which of the following is a renewable resource?

(a) coal
(b) iron
(c) air
(d) salt

_____ 49. An example of a particulate is

(a) mist.
(b) ozone.
(c) carbon monoxide.
(d) sulphur dioxide.

_____ 50. Acid rain is a result of the pollutant emission of

(a) PCB and PVC.
(b) NO_2 and SO_2.
(c) CO_2 and CO.
(d) O_3 and soot.

_____ 51. A carbon atom has four electrons in its outer energy level. It requires eight electrons in this level to form a stable compound. Carbon atoms obtain extra electrons by

(a) stripping other atoms of their electrons.
(b) forming covalent bonds with other atoms.
(c) trapping free-floating electrons from the surrounding environment.
(d) forming ionic bonds with other atoms.

_____ 52. Which of the following groups of organic compounds is composed entirely of carbon, hydrogen and oxygen?

(a) lipids and proteins
(b) carbohydrates and nucleic acids
(c) carbohydrates and lipids
(d) proteins and nucleic acids

_____ 53. Two monosaccharides are joined together to form a disaccharide by a chemical process known as

(a) hydrolysis.
(b) denaturation.
(c) deanimation.
(d) dehydration synthesis.

______ 54. Proteins are synthesized in the cytoplasm of eukaryotic cells by the

(a) ribosomes.
(b) mitochondria.
(c) Golgi apparatus.
(d) endoplasmic reticulum.

______ 55. The three bases on the end of the tRNA molecule are called the

(a) codon.
(b) anticodon.
(c) enzyme complex.
(d) activation site.

______ 56. The process by which DNA builds an exact copy of itself is known as

(a) replication.
(b) respiration.
(c) duplication.
(d) dehydration synthesis.

______ 57. Which of the following is **not** a difference between DNA and RNA?

(a) They are composed of different sugars.
(b) They have one base that is different.
(c) DNA is found in the nucleus; RNA is not.
(d) One is single-stranded; the other is double-stranded.

______ 58. A piece of DNA reads A—T—G—T—C—C. Transcription occurs, resulting in the production of an mRNA strand which reads

(a) T—U—C—U—G—G.
(b) C—G—A—G—T—T.
(c) U—A—C—A—G—G.
(d) T—A—C—A—G—G.

______ 59. How many different kinds of tRNA are there in a cell?

(a) 3
(b) 16
(c) 20
(d) one for every three amino acids

Use the following information to answer question 60.

Base sequence on mRNA	Amino acid
AAG	lysine
AUC	isoleucine
AGC	serine
UAC	tyrosine
UUC	phenylalanine
UGC	cysteine

______ 60. Determine the amino acids and the sequence in which they are joined if the sequence of bases on a strand of DNA are: ACGATGTAG.

(a) serine, cysteine, lysine
(b) cysteine, isoleucine, phenylalanine
(c) serine, phenylalanine, lysine
(d) cysteine, tyrosine, isoleucine

______ 61. Chromosomes which are similar in size and shape and carry genetic information for the same traits are said to be

(a) homozygous.
(b) homologous.
(c) heterozygous.
(d) diploid.

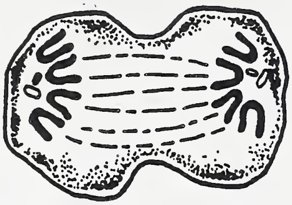
______ 62. The term mitosis refers to

(a) the separation of chromosomes during cell division.
(b) the process of cellular division which results in the production of two, smaller daughter cells.
(c) a series of cell divisions which reduces the chromosome number from 2n to 1n.
(d) the stage of cell division during which cells are not actively dividing.

______ 63. If a biologist were to examine a small portion of skin tissue under a microscope, which stage of cell division would most of the cells be in?

(a) telophase
(b) interphase
(c) prophase
(d) metaphase

Use the following diagram of a cell to answer questions 64 and 65.



______ 64. What phase of mitosis is illustrated in the above diagram?

(a) prophase
(b) anaphase
(c) metaphase
(d) telophase

______ 65. How many chromosomes are present in the cell?

(a) 0
(b) 4
(c) 8
(d) 16

______ 66. One method of asexual reproduction in single-celled organisms is

(a) mitosis.
(b) meiosis.
(c) the production of spores.
(d) spermatogenesis.

______ 67. The proper number of chromosomes present in each gamete

(a) is the diploid number.
(b) is the haploid number.
(c) is the same for all species.
(d) varies with each individual organism.

______ 68. Meiosis occurs in sexually reproducing organisms

(a) to prevent asexual reproduction.
(b) to allow for the production of a maximum number of gametes.
(c) to decrease genetic variability within a species.
(d) to prevent the number of chromosomes from doubling in future generations.

______ 69. The normal diploid number of chromosomes in corn is 20. Therefore, each mature gamete of a corn plant would have a chromosome number of

(a) 5.
(b) 10.
(c) 20.
(d) 40.

______ 70. In humans, the presence of an extra chromosome in pair 21 results in the condition known as

(a) Down's syndrome.
(b) Turner's syndrome.
(c) Klinefelter's syndrome.
(d) Albinism.

______ 71. Hornless is dominant over horned in cattle. A farmer has a herd of hornless cattle. From time to time a horned calf appears in his herd. The reason for this is that

(a) a mutation is taking place.
(b) all are homozygous hornless.
(c) some are heterozygous.
(d) the environment influences the growth of horns.

______ 72. One gene of a pair masks or hides the expression of a partner allele. This illustrates Mendel's

(a) law of dominance.
(b) law of segregation.
(c) law of independence.
(d) law of independent assortment.

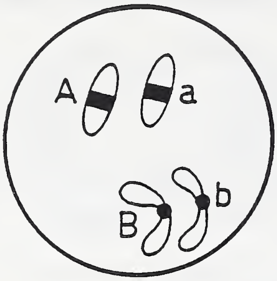
______ 73. Determine the genotypes of the parents which when crossed produce an F_1 generation consisting entirely of the Rr genotype.

(a) RR × Rr
(b) Rr × rr
(c) Rr × Rr
(d) RR × rr

_____ 74. Suppose a geneticist crossed a pea plant having green seeds with another plant having yellow seeds. If two of these offspring were then cross-pollinated, what generation would **their** offspring be?

(a) parental generation
(b) F_1 generation
(c) F_2 generation
(d) third filial generation

Use the following diagram to answer question 75.



_____ 75. If the cell in the diagram above were to undergo meiotic division, the possible allelic combinations of the gametes would be

(a) Ab, ab
(b) Aa, Bb, AB, ab
(c) AB, Ab, Ba
(d) AB, aB, Ab, ab

_____ 76. The probability of "tossing a coin" three times and having it land heads all three times would be

(a) 1/8
(b) 1/6
(c) 1/2
(d) 3/3

_____ 77. In determining the size of watermelon fruit, let L = large melons and l = small melons. If an LL plant is crossed with a heterozygous individual, what is the probability of offspring with the homozygous dominant genotype?

(a) 25%
(b) 50%
(c) 75%
(d) 100%

Use the following information to answer questions 78 and 79.

AABb	AAbb	AaBb	Aabb
AaBb	Aabb	aaBb	aabb
AABb	AAbb	AaBb	Aabb
AaBb	Aabb	aaBb	aabb

______ 78. The above Punnett square includes the genotypes of all possible offspring resulting from a cross of individuals with the genotypes

(a) AaBb and AaBb.
(b) AABB and aabb.
(c) AABb and AAbb.
(d) AaBb and Aabb.

______ 79. The probability of having offspring that are heterozygous for both traits in the above cross would be

(a) 1/8.
(b) 1/4.
(c) 1/2.
(d) 9/16.

______ 80. In fruit flies, grey body color is dominant to black body color. If a single pair of genes controls this trait, then the genotype of a homozygous recessive individual would be

(a) gg.
(b) GG.
(c) BB.
(d) bb.

______ 81. Walter S. Sutton and Theodor Boveri each independently developed

(a) fruit fly mutations.
(b) the chromosome theory.
(c) the theory of natural selection.
(d) the one-gene, one-enzyme hypothesis.

_____ 82. If coat color in cats is a sex-linked trait and the letter B represents the dominant, black coat color, the genotype of a male black cat would be

(a) X^BX^B.
(b) X^BY^B.
(c) X^BY.
(d) XY^B.

Use the following information to answer questions 83 and 84.

In humans, color blindness is a sex-linked trait. The allele for normal color vision is represented by an uppercase "C" and the allele for color blindness by a lowercase "c." A man with normal color vision and a woman who is a carrier for color blindness have children.

_____ 83. The genotypes of the parents would be

(a) X^CY and X^CX^c.
(b) X^cY and X^cX^c.
(c) X^cY and X^CX^C.
(d) X^CY and X^cX^c.

_____ 84. If the child is a boy, he

(a) will be color blind.
(b) will not be color blind.
(c) will be a carrier.
(d) might be either (a) or (b).

_____ 85. Which set of parents could produce a child with Type O blood?

(a) $I^aI^b \times ii$
(b) $I^aI^b \times I^ai$
(c) $I^ai \times I^aI^a$
(d) $I^ai \times I^bi$

_____ 86. Albinism and sickle-cell anemia are human conditions caused by

(a) gene mutations.
(b) chromosomal mutations.
(c) somatic mutations.
(d) lethal genes.

Use the following information to answer questions 87 and 88.

Tallness (T) is dominant to dwarfness (t) while flower color demonstrates incomplete dominance in snapdragons. This means that a cross between a red flower (RR) and a white flower (WW) produces pink-flowered offspring (RW).

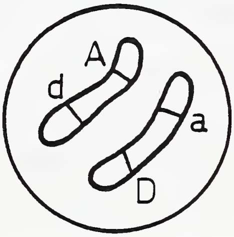
_____ 87. A heterozygous tall, pink snapdragon is crossed with a plant which is homozygous for tallness and red flowers. What would be the probability of producing a tall, white offspring?

(a) 0%
(b) 6.25%
(c) 28.125%
(d) 56.25%

_____ 88. What would be the genotype of a heterozygous tall, pink snapdragon?

(a) TTPp
(b) TtRW
(c) TTRW
(d) TtRr

Use the illustration below to answer question 89.



_____ 89. If the cell in the diagram were to undergo meiotic division, the possible allelic combinations of gametes would be

(a) AD, ad
(b) Ad, aD
(c) Ad, aD, Aa, Dd
(d) AD, ad, Ad, aD

_____ 90. During meiosis, adjacent chromatids sometimes twist and break. The broken sections fuse to different but homologous chromosomes resulting in new gene combinations. This process is known as

(a) gene mutation.
(b) linkage.
(c) crossing-over.
(d) sexual recombination.

_____ 91. An organism with a 4n chromosome number is

(a) very complex.
(b) in the act of reproducing.
(c) a polyploid.
(d) more complex than organisms with the 2n chromosome number.

_____ 92. Chromosomal mutations, in which the broken-off piece of a chromosome becomes attached to a homologous chromosome, are called

(a) deletion.
(b) inversion.
(c) translocation.
(d) duplication.

_____ 93. Mules are the offspring of horses and donkeys. Mules cannot mate to produce more mules because the males are sterile. We can conclude then that

(a) mules are a new species.
(b) horses and donkeys are in the same species.
(c) horses and donkeys are in different species.
(d) donkeys are subspecies of horses.

_____ 94. Genes which are harmful and recessive can remain in a population of organisms because they are

(a) kept for future survival value.
(b) needed to control population size.
(c) carried by individuals that are heterozygous.
(d) only eliminated by an increase in mutation rate.

_____ 95. A high rabbit population is found in a given geographical location. This would indicate that

(a) the average age of the population has increased.
(b) the birth rate of the rabbits is low.
(c) the ratio of predators to rabbits is higher than usual.
(c) rabbits in this locality are well adapted to their environment.

_____ 96. What will happen to a mutant allele if it gives an organism a slight advantage?

(a) It will soon be eliminated from the gene pool because it is mutant.
(b) It will become a part of the gene pool and have a selective advantage.
(c) Its effects will not be noticed because genes will mask it.
(d) The mutants would be considered a new species after 20 generations.

_____ 97. Which of the following did **not** supply Darwin with any evidence for his theory of evolution?

(a) fossil evidence
(b) genetic evidence
(c) embryological evidence
(d) evidence from artificial selection

______ 98. Two populations of the same species are geographically separated. Genetic isolation **cannot** develop if

(a) migration of individuals between the two populations occurs.
(b) genetic drift occurs.
(c) the environments are different.
(d) different mutations appear in the separated populations.

______ 99. Evolution takes place more rapidly among sexually reproducing organisms than asexually reproducing organisms because

(a) sexual reproduction is more hazardous than asexual reproduction.
(b) sexual reproduction is more likely to produce a variety of offspring.
(c) sexual reproduction is slower than asexual reproduction in producing offspring.
(d) asexual reproduction is possible only for unicellular organisms.

______ 100. The present-day horse is much larger than its original ancestors. Which statement below helps to explain this change, based on Lamarck's reasoning?

(a) Sometime in the past a mutation occurred.
(b) Larger horses survived, smaller ones perished, thus leaving only the bigger animals.
(c) Larger horses produced more offspring than smaller horses, thus changing the genetic makeup of each population.
(d) Early horses had to become larger because they needed longer legs and stronger muscles to outrun predators.

Submit pages 3 to 21 of this lesson for correction.

END OF LESSON 12

N.L.C. - B.N.C.
3 3286 10376975 4